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ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, COASTAL PLAIN RESOURCE ASSESSMENT

REPORT AND RECOMMENDATION TO THE CONGRESS OF THE UNITED STATES
AND FINAL LEGISLATIVE ENVIRONMENTAL IMPACT STATEMENT



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U.S. Department of the Interior

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UNITED STATES
DEPARTMENT OF THE INTERIOR

ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA,
COASTAL PLAIN RESOURCE ASSESSMENT

REPORT AND RECOMMENDATION TO THE CONGRESS OF THE UNITED STATES
AND FINAL LEGISLATIVE ENVIRONMENTAL IMPACT STATEMENT



APRIL 1987

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In accordance with Section 1002 of the
Alaska National Interest Lands Conservation Act,
and the National Environmental Policy Act

Prepared by the U.S. Fish and Wildlife Service
in cooperation with U.S. Geological Survey
and the Bureau of Land Management

**ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA,
COASTAL PLAIN RESOURCE ASSESSMENT**

**Report and recommendation to the Congress of the United States
and final legislative environmental impact statement, 1987**

**Volume 1--Report
Volume 2--Appendix (Public comments and responses)**

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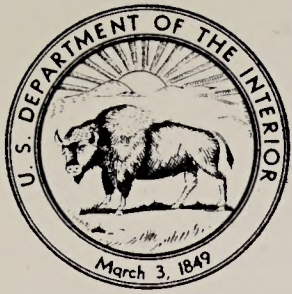
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Recommended citation for this report:

Clough, N. K.; Patton, P. C.; and Christiansen, A. C., editors, 1987, Arctic National Wildlife
Refuge, Alaska, coastal plain resource assessment--Report and recommendation to the
Congress of the United States and final legislative environmental impact statement:
Washington, D. C., U.S. Fish and Wildlife Service, U.S. Geological Survey, and Bureau of
Land Management, v. 1 (Report)--xviii + 208 p., 5 pls., 32 figs., 26 tables; v. 2 (Appendix--
Public comments and responses)--ii + 998 p.

COVER PHOTOGRAPH

A typical view southward across the coastal plain
toward the foothills and the Brooks Range.



THE SECRETARY OF THE INTERIOR
WASHINGTON

April 21, 1987

Dear Reader:

The Alaska National Interest Lands Conservation Act (ANILCA) of 1980 set aside more than 100 million acres of land in Alaska as national parks, preserves, wildlife refuges, and wilderness areas. At that time, the Congress specifically left open the question of future management of the 1.5-million-acre coastal plain of the 19-million-acre Arctic National Wildlife Refuge because of the area's potentially enormous oil and gas resources and its important wildlife values.

ANILCA directed the Department of the Interior to conduct biological and geological studies of the Arctic Refuge coastal plain, and to provide the Congress with the results of those studies and a recommendation on future management of the area. The following report culminates more than 5 years of biological baseline studies, surface geological studies, and two seasons of seismic exploration surveys. The Arctic Refuge coastal plain is rated by geologists as the most promising onshore oil and gas exploration area in the United States. It is estimated to contain more than 9 billion barrels of recoverable oil, an amount approximately equal to Prudhoe Bay, which currently provides one-fifth of U.S. domestic oil production.

In 1986, U.S. domestic oil production dropped 9 to 10 percent; production is predicted to drop an additional 4 to 5 percent in 1987, if prices do not drop this year. At the same time, U.S. oil consumption, which has exceeded domestic production since the 1960's, is expected to increase. Our oil imports are projected to exceed 50 percent of consumption in the 1990's. America's growing reliance on imported oil for the rest of the century could have potentially serious ramifications for our national security.

The following report analyzes the potential environmental consequences of five management alternatives for the coastal plain, ranging from opening for lease of the entire area for oil and gas development, to wilderness designation. A legislative environmental impact statement has been integrated into the report.

Public hearings were held in January 1987 on a draft report and recommendation. These hearings were attended by representatives of the Governments of Canada and Alaska, Alaska Natives, other interested parties, and the general public. Seven thousand of the 11,000 comments received favored opening the Arctic Refuge coastal plain for oil and gas leasing and development.

Based on the analyses conducted, public comment on the draft report, the national need for domestic sources of oil and gas, and the Nation's ability to develop such resources in an environmentally sensitive manner as demonstrated by two decades of success at Prudhoe Bay and elsewhere, I have selected as my preferred alternative, making available for consideration the entire Arctic Refuge coastal plain for oil and gas leasing. Although the entire area should be considered for leasing, only a percentage would actually be leased, an even smaller percentage would be explored, and--if oil is discovered--a still smaller percentage would be developed.

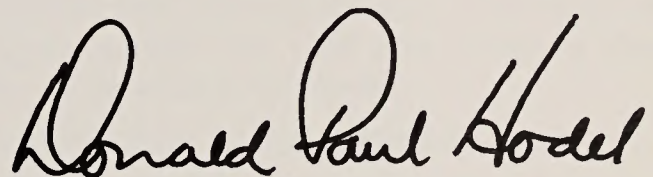
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The step-by-step environmental planning, review, and evaluation procedures included in a leasing program provide the best opportunity for the Department to decide what areas to lease, based on the most accurate and advanced information available at each step of the leasing process. Although the exact process depends upon the leasing program established by the Congress, compliance with the National Environmental Policy Act is required for each lease sale, exploration plan, and development and production plan.

The following report provides information critical for the Congress to consider in determining the future management of the Arctic Refuge coastal plain. The Congress must enact legislation to authorize an oil and gas leasing program for the area. We will work with the Congress to ensure that any leasing program developed will avoid unnecessary adverse effects on the environment.

Legislative proposals are currently in the Congress to establish the formula for sharing with the State of Alaska any revenues from an oil and gas leasing program in the Arctic Refuge coastal plain. There also is a proposal that would direct a portion of the Federal share of such revenues to conservation activities. We look forward to working with the Congress on such matters as well as in determining future management of the Arctic Refuge coastal plain. My preliminary recommendation (Chapter VIII) will become final upon formal transmittal to the Congress of the following report.

Sincerely,

A handwritten signature in black ink that reads "Donald Paul Hodel". The signature is written in a cursive style with a large, prominent initial "D".

DONALD PAUL HODEL

SUMMARY

ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, COASTAL PLAIN RESOURCE ASSESSMENT Report and Recommendation to the Congress/Final Legislative Environmental Impact Statement APRIL 1987

Prepared by the U.S. Fish and Wildlife Service, in cooperation with the U.S. Geological Survey and the Bureau of Land Management, Department of the Interior, Washington, D.C. 20240.

TYPE OF ACTION

Recommendation for legislative action concerning future management of the 1.5-million-acre coastal plain of the 19-million-acre Arctic National Wildlife Refuge (referred to herein as the "1002 area"), located in northeastern Alaska.

DESCRIPTION OF THE PROPOSED ACTION

The Secretary of the Interior recommends to the Congress of the United States that it enact legislation directing the Secretary to conduct an orderly oil and gas leasing program for the 1002 area at such pace and in such circumstances as he determines will avoid unnecessary adverse effect on the environment.

The 1002 area is the Nation's best single opportunity to increase significantly domestic oil production. It is rated by geologists as the most outstanding petroleum exploration target in the onshore United States. Data from nearby wells in the Prudhoe Bay area and in the Canadian Beaufort Sea and Mackenzie Delta, combined with promising seismic data gathered on the 1002 area, indicate extensions of producing trends and other geologic conditions exceptionally favorable for discovery of one or more supergiant fields (larger than 500 million barrels).

There is a 19-percent chance that economically recoverable oil occurs on the 1002 area. The average of all estimates of conditional economically recoverable oil resources (the "mean") is 3.2 billion barrels. Based on this estimate, 1002 area production by the year 2005 could provide 4 percent of total U.S. demand; provide 8 percent of U.S. production (about 660,000 barrels/day); and reduce imports by nearly 9 percent. This production could provide net national economic benefits of \$79.4 billion, including Federal revenues of \$38.0 billion.

ENVIRONMENTAL EFFECTS

Potential impacts were assessed for exploration, development drilling, and production. Impacts predicted for exploration and development drilling were minor or negligible on all wildlife resources on the 1002 area. Production of oil is expected to directly affect only 12,650 acres or 0.8 percent of the 1002 area. Consequences on species such as brown bears, snow geese, wolves, moose, and the Central Arctic caribou herd are expected to be negligible, minor, or moderate.

Potential major effects on wildlife from production are limited to the Porcupine caribou herd and reintroduced muskoxen. "Major biological effects" were defined as: "widespread, long-term change in habitat availability or quality which would likely modify natural abundance or distribution of species. Modification will persist at least as long as modifying influences exist."

The Porcupine caribou herd has shown some preference for calving on the 1002 area including the upper Jago River area (84,000 acres or 5.4 percent of the 1002 area). A potential consequence would be displacement of portions of the herd seeking to calve in the upper Jago River area--the case only if the area were the site of a major producing oil field. It is unlikely, though possible, that such displacement would result in any appreciable decline in herd size.

The potential effects of oil and gas activities on the area's muskoxen are unknown, although biologists predict that major effects could be: (1) substantial displacement from currently used habitat and (2) a slowing of the herd's growth rate, as distinguished from a diminution in herd size.

Potential effects on Native subsistence fall into two categories: the village of Kaktovik and villages outside the 1002 area. In the case of Kaktovik, a major restriction of subsistence activities could occur. This would likely result from the physical changes proximate to Kaktovik which could interfere with traditional activities. Subsistence effects on villages outside the 1002 area, including those in Canada, are expected to be minimal.

ALTERNATIVES TO THE PROPOSED ACTION

Alternatives for the Congress that were discussed in the report and legislative environmental impact statement include: (1) Authorize leasing limited to a part of the 1002 area based on environmental considerations (Alternative B); (2) authorize further exploration only, including exploratory drilling (Alternative C); (3) continue current refuge status with no further oil and gas activity allowed (Alternative D); and (4) designate the area as wilderness (Alternative E). For purposes of environmental impact statement analysis, Alternative D is considered the "no action" alternative.

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ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, COASTAL PLAIN RESOURCE ASSESSMENT
Final report and legislative environmental impact statement, 1987

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ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, COASTAL PLAIN RESOURCE ASSESSMENT

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ACRONYMS AND ABBREVIATIONS

ADEC	Alaska Department of Environmental Conservation	MOU	memorandum of understanding
ADF&G	Alaska Department of Fish and Game	mph	miles per hour
AGL	above ground level	MP _{HC}	marginal probability for hydrocarbons
AMRAP	Alaska Mineral Resource Assessment Program	NAAQS	national ambient air quality standards
		NARL	Naval Arctic Research Laboratory (Barrow)
ANCSA	Alaska Native Claims Settlement Act of 1971	NEPA	National Environmental Policy Act of 1969
ANGTS	Alaska Natural Gas Transportation System	NEPP	National Energy Policy Plan
ANILCA	Alaska National Interest Lands Conservation Act of 1980	NNEB	net national economic benefit
ANS	Alaskan North Slope	NNSDC	Newport News Shipbuilding and Drydock Company
AS	Alaska Statute	NOAA	National Oceanic and Atmospheric Administration
ASRC	Arctic Slope Regional Corporation	NPRA	National Petroleum Reserve in Alaska
BBO	billion barrels of oil	NSB	North Slope Borough
BLM	Bureau of Land Management	O ₃	ozone
CAH	Central Arctic caribou herd	OCS	Outer Continental Shelf
CCP	Comprehensive conservation plan	OPEC	Organization of Petroleum Exporting Countries
CEQ	Council on Environmental Quality	Members:	
CFR	Code of Federal Regulations	Algeria	Libya
COST	Continental Offshore Stratigraphic Test	Ecuador	Nigeria
CPF	central production facility	Gabon	Qatar
		Indonesia	Saudi Arabia
DCF	discounted cash flow	Iran	United Arab Emirates
DEIS	draft environmental impact statement	Iraq	Venezuela
DEW Line	Distant Early Warning Line	Kuwait	
DO	dissolved oxygen		
DOE	U.S. Department of Energy	PCH	Porcupine caribou herd
EIA	Energy Information Administration	P.L.	public law
EIS	environmental impact statement	PM	particulate matter
EOR	enhanced oil recovery	ppm	parts per million
FASP	Fast Appraisal System for Petroleum	ppt	parts per thousand
FEIS	final environmental impact statement	PRESTO	Probabilistic Resource Estimates--Offshore
		PSD	prevention of significant deterioration of air quality program
FR	Federal Register	Stat.	Statute
FWS	U.S. Fish and Wildlife Service		
GS	U.S. Geological Survey	TAGS	Trans-Alaska Gas System
ha	hectare	TAPS	Trans-Alaska Pipeline System
KIC	Kaktovik Inupiat Corporation	TCFG	trillion cubic feet of gas
		TIAS	Treaties and other International Acts Series
kg	kilogram	TS	Treaty Series
LEIS	legislative environmental impact statement		
LNG	liquefied natural gas	TSP	total suspended particulates
MBO	million barrels of oil	U.S.C.	United States Code
MBO/D	million barrels of oil per day	U.S.T.	United States Treaty
		VSM	vertical support member
MBO/Y	million barrels of oil per year	YPC	Yukon Pacific Corporation
MCF	thousand cubic feet (of gas)		
MEFS	minimum economic field size		



ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, COASTAL PLAIN RESOURCE ASSESSMENT

CHAPTER I

INTRODUCTION

BACKGROUND

The Arctic National Wildlife Refuge, in the northeastern corner of Alaska, was first established as the Arctic National Wildlife Range by Public Land Order 2214 in 1960, for the purpose of preserving unique wildlife, wilderness, and recreational values. The original 8.9-million-acre Range was withdrawn from all forms of appropriation under the public land laws, including mining laws but not including mineral leasing laws. This order culminated extensive efforts begun more than a decade earlier to preserve this unique part of Alaska.

The Alaska National Interest Lands Conservation Act (ANILCA), passed in 1980, established 16 National Wildlife Refuges in Alaska, among them the 19-million-acre Arctic National Wildlife Refuge, hereafter referred to as Arctic Refuge. The Arctic Refuge today encompasses the existing 8.9-million-acre wildlife range and approximately 10 million additional acres of adjoining lands west toward the Trans-Alaska Pipeline System (TAPS) and south to the Yukon Flats. Approximately 8 million acres, comprising most of the original Arctic National Wildlife Range, was designated wilderness.

ANILCA also redefined the purposes of the Arctic Refuge:

- (i) To conserve fish and wildlife populations and habitats in their natural diversity including, but not limited to, the Porcupine caribou herd (including participation in coordinated ecological studies and management of this herd and the Western Arctic caribou herd), polar bears, grizzly bears, muskoxen, Dall sheep, wolves, wolverines, snow geese, peregrine falcons and other migratory birds, and Arctic char and grayling;

- (ii) To fulfill the international treaty obligations of the United States with respect to fish and wildlife and their habitats;
- (iii) To provide, in a manner consistent with the purposes set forth in subparagraphs (i) and (ii), the opportunity for continued subsistence uses by local residents; and
- (iv) To ensure, to the maximum extent practicable and in a manner consistent with the purposes set forth in paragraph (i), water quality and necessary water quantity within the refuge.

The Arctic Refuge offers wildlife, scientific, recreational, and esthetic values unique to the Arctic coastal ecosystem. In the Arctic Refuge, a person traveling on foot or by boat can traverse a full range of North Slope landscapes and habitats, because of the proximity of the Arctic coast to the mountains. Mt. Chamberlin, 9,020 feet; Mt. Isto, 8,975 feet; Mt. Hubley, 8,915 feet; and Mt. Michelson, 8,855 feet--the four tallest peaks in the Brooks Range--are in the Arctic Refuge. The Arctic Refuge contains the only extensive active glaciers in the Brooks Range. Found on the refuge is a full complement of arctic flora and fauna, including the calving grounds for the Porcupine caribou herd, one of the largest in Alaska (approximately 180,000 caribou), and habitat for the threatened arctic peregrine falcon, lesser snow goose, and other migratory bird species, and reintroduced muskoxen.

During the 1970's the Alaskan arctic coastal plain was the site of several studies on oil and gas potential, possible oil and gas transportation corridors, and biological resources (U.S. Department of the Interior, 1972, 1976).

The Alaska Natural Gas Transportation System studies on the Range included extensive biological studies, as did studies for the planning and development of the TAPS to the west of the Range.

During the 7 years ANILCA was being considered in the Congress, and particularly during 1977-80, the issue of oil and gas exploration and development on the 1.55-million-acre Arctic Refuge coastal plain was fully debated. Some members wanted the coastal plain designated as wilderness, and some favored opening it to oil and gas leasing. As explained in the 1979 Senate Report:

"The Committee was particularly concerned with the ANWR [Arctic National Wildlife Range]. In hearings and in markup, conflicting and uncertain information was presented to the committee about the extent of oil and gas resources on the Range and the effect development and production of those resources would have on the wildlife inhabiting the Range and the Range itself. The nationally and internationally recognized wildlife and wilderness values of the Range are described in the discussion of the Committee amendments to Title III. The Committee was determined that a decision as to the development of the Range be made only with

adequate information and the full participation of the Congress." [Senate Report 413, 96th Cong. 1st Sess. at 241(1979)].

Therefore, the Congress created section 1002 of ANILCA to deal with the issue.

PURPOSE AND NEED FOR THIS REPORT

Specifically, section 1002 of ANILCA requires the Secretary of the Interior:

1. To conduct a comprehensive, continuing baseline study of the fish and wildlife resources of the Arctic Refuge 1002 area (fig. I-1). [Throughout this report the term "1002 area" refers to that part of the Arctic Refuge defined as the "coastal plain" by section 1002(b) of the ANILCA];
2. To develop guidelines for, initiate, and monitor an oil and gas exploration program; and

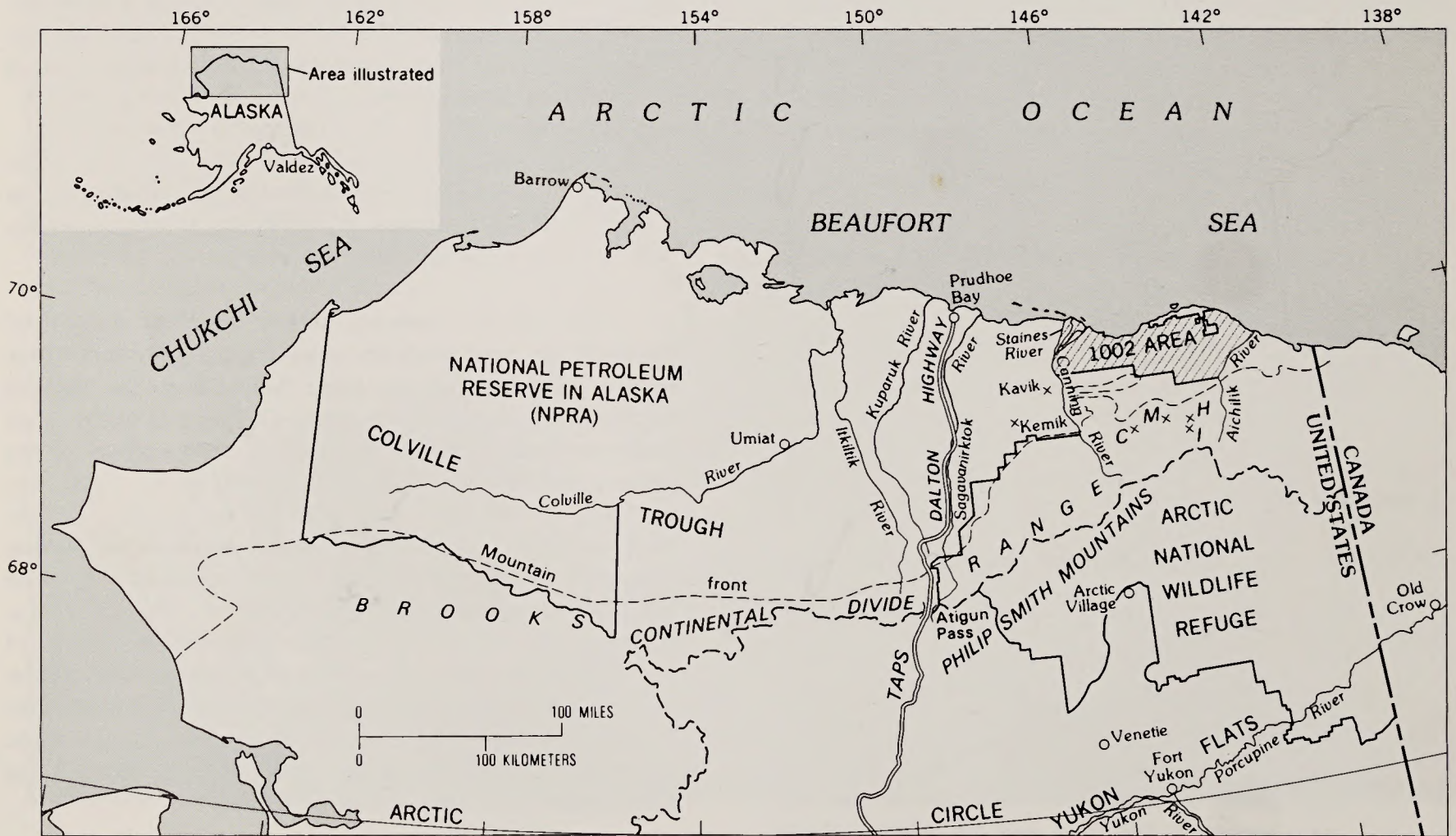


Figure I-1.--Index map of northern Alaska showing location of 1002 area in relation to the Arctic National Wildlife Refuge (Arctic Refuge), the National Petroleum Reserve in Alaska (NPR), and Prudhoe Bay. Four highest peaks in the Brooks Range: C, Mt. Chamberlin; I, Mt. Isto; H, Mt. Hubley; M, Mt. Michelson.

3. To prepare a "Report to Congress" which describes the fish and wildlife resources of the 1002 area; identifies and estimates the volume and areal extent of potential hydrocarbon resources; assesses the potential impacts of development; discusses transportation of oil and gas; discusses the national need for domestic sources of oil and gas; and recommends whether further exploration, development, and production of oil and gas should be allowed.

The U.S. Fish and Wildlife Service (FWS) has lead responsibility for meeting these Congressional mandates. Under an interagency memorandum of understanding (MOU) dated June 1983, the Bureau of Land Management (BLM) and the Geological Survey (GS) have assisted the FWS by providing technical expertise in reviewing industry-proposed exploration plans, conducting geologic studies and assessing the hydrocarbon potential of the 1002 area, as well as developing this report. The status of these activities is reported herein.

BASELINE STUDY OF FISH AND WILDLIFE RESOURCES

The FWS began biological baseline studies of selected fish and wildlife species of the 1002 area during the spring of 1981. An initial baseline report that described the 1981 field season (spring-fall) and reviewed existing literature was published in April 1982. The results of subsequent field seasons (1982-85) were documented in four annual baseline update reports and a final baseline report. (See "References cited" for the listing of these publications.) The final baseline report was published in December 1986.

The 1002 area baseline studies represent more than 60 staff-years of research effort (that is, data collection, analysis, and synthesis). Fifty-seven separate field studies defined (1) the ecology, distribution, and abundance of fish and wildlife species, (2) wildlife habitats within the 1002 area, and (3) the impacts of seismic exploration on tundra vegetation.

Section 303 of ANILCA, which reestablished existing refuges, specified that a purpose of the Arctic Refuge was to conserve fish and wildlife populations. Among the species or groups of species mentioned in section 303(2)(B)(i) that were studied on the 1002 area were caribou, muskoxen, wolves, brown bear, wolverines, migratory birds, and fish, as well as the vegetation. The Fish and Wildlife Service staff was assisted by the State of Alaska Department of Fish and Game, Canadian Wildlife Service, Yukon Department of Renewable Resources, researchers from the Cooperative Wildlife Research Unit at the University of Alaska, and volunteers. Investigative techniques included visual observations, aerial censuses, radio telemetry, and satellite tracking. These baseline studies of the 1002 area are the basis for the description of the biological environment in Chapter II and the analysis of environmental consequences in Chapter VI.

OIL AND GAS EXPLORATION PROGRAMS

Section 1002(a) of ANILCA authorized oil and gas exploration on the 1002 area in a manner that would avoid significant adverse effects on fish, wildlife, and other resources. Exploration included surface geological and geophysical work but not exploratory drilling.

The FWS published an environmental impact statement in February 1983, and final regulations governing exploration on the 1002 area were published in the Federal Register on April 19, 1983 (48 Federal Register 16838-16872; 50 CFR 37). As required by section 1002(d), the regulations were developed to ensure that exploratory activities did not have a significant adverse effect on fish and wildlife, their habitats, or the environment (FWS and others, 1982, 1983).

~ During the summers of 1983-85, exploration crews from 15 companies visited the 1002 area. No surface vehicles were allowed; access was by helicopter. The work involved field observations, surface measurements, mapping, and collection of rock samples. Samples were analyzed for age and geochemistry (hydrocarbon-generation potential) and porosity and permeability (hydrocarbon-reservoir potential). The FWS carefully monitored all activities, and no adverse effects on fish or wildlife were observed from helicopter-supported surface exploration during summer months. ~¹

The FWS issued one permit for a helicopter-supported gravity survey that was conducted during the late summer of 1983. The permittee (International Technology Ltd.) collected approximately 1,300 gravity readings from the ground along a 1x2-mile grid covering the entire 1002 area.

During the winter months, when most wildlife species were absent or were present in lesser numbers, seismic operations were permitted. More than 1,300 line miles of seismic data was acquired during the winters of 1983-1984 and 1984-1985. The seismic program provided subsurface data on the area's oil and gas potential. As the only exploration technique involving mechanized surface transportation, it posed the greatest possibility of adverse environmental effects. Therefore, to avoid significant adverse impacts, the FWS:

1. Allowed only one permittee (Geophysical Service Inc.), representing an industry group of 23-25 companies, to collect seismic data,
2. Restricted activities in sensitive wildlife areas (such as near bear dens) or where snow cover was insufficient to protect the tundra,

¹Symbol indicates modification of draft report. See page 6 for full explanation of symbols.

3. Limited the number of line miles of seismic survey to only that amount necessary to yield data from which to develop a credible oil and gas resource assessment, and
4. Placed full-time FWS monitors on each seismic crew.

By restricting or rerouting overland travel in areas of inadequate snow cover or sensitive vegetation, the monitors effectively limited adverse environmental impacts. They also collected data on the severity of the seismic surveys' surface impact in relation to snow depth, topography, and vegetation type. Several more seasons of followup studies on long-term impacts, if any, will supplement their observations of short-term surface disturbance.

REPORT PREPARATION

Under provisions of the MOU, an "Interagency Advisory Work Group" was formed in March 1984 to oversee the preparation of this report. The work group, headed by the FWS, comprised FWS, GS, and BLM representatives. The group called on more than 50 technical experts within the three bureaus to contribute to various sections of this report. Contributors are listed at the front of this report.

This document provides the basis for the Secretary of the Interior's recommendation to the Congress concerning future management of the 1002 area. The document fulfills the requirements of both section 1002(h) of ANILCA and section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969.

Section 1002(h) of ANILCA mandates that the report must contain:

1. The identification, by means other than drilling of exploratory wells, of those areas within the coastal plain that have oil and gas production potential and an estimate of the volume of the oil and gas concerned (Chapter III).
2. The description of the fish and wildlife, their habitats, and other resources that are within the areas identified under paragraph (1) (Chapter II).
3. An evaluation of the adverse effects that the carrying out of further exploration for, and the development and production of, oil and gas within such areas may have on the resources referred to in paragraph (2) (Chapter VI).
4. A description of how such oil and gas, if produced within such area, may be transported to processing facilities (Chapter IV).
5. An evaluation of how such oil and gas relates to the national need for additional domestic sources of oil and gas (Chapter VII).

6. The recommendations of the Secretary with respect to whether further exploration for, and the development and production of, oil and gas within the coastal plain should be permitted and, if so, what additional legal authority is necessary to ensure that adverse effects of such activities on fish and wildlife, their habitats, and other resources are avoided or minimized (Chapter VIII).

~ The first seven chapters of this report also constitute a legislative environmental impact statement (LEIS) pursuant to section 1506.8 of the Council on Environmental Quality's (CEQ) regulations to implement NEPA (40 CFR 1500-1508). Chapters V and VI in particular discuss and evaluate five major alternatives from which the Secretary's recommendation (Chapter VIII) has been derived. Those alternatives are for the Congress to: (A) authorize full leasing of the entire 1002 area; (B) authorize leasing limited to a part of the 1002 area; (C) authorize further exploration, including exploratory drilling, only; (D) continue current refuge status with no further oil and gas activity allowed; and (E) designate the area as wilderness. For the purpose of EIS (environmental impact statement) analysis, alternative A is considered the "proposed action" and Alternative D is considered the "no action" or baseline alternative. ~

Estimates of conditional economically recoverable resources described in Chapter III form the basis for hypothetical oil exploration, development, production, and transportation scenarios outlined in Chapter IV which are used in the LEIS to determine and measure environmental impacts, and to discuss the national need in Chapter VII.

~ Any Congressionally authorized oil and gas program on the 1002 area would have some degree of cumulative effect with other existing and potential activities on the North Slope of Alaska, including State and Federal offshore leasing programs, oil and gas exploration programs to the east in the Canadian Arctic, and further Federal or State leasing on the North Slope. Also possible is the further expansion of oil and gas activities in and around Prudhoe Bay. Chapter VI includes a general discussion of the potential for cumulative effects. Where information is available for a particular species, cumulative effects are added to the individual impact discussions. ~

~ Leasing and operations would be subject to all appropriate Federal and State regulations and further environmental evaluation at appropriate stages of the development. Depending on the decision of the Congress, this programmatic LEIS may suffice for initial leasing. However, exploration proposals normally require site-specific NEPA evaluations, and a development and production proposal would require a site-specific EIS. Any future EIS on development of the 1002 area would, to the extent appropriate, be tiered on this programmatic LEIS. ~

~ PUBLIC INVOLVEMENT ~

~ If leases are eventually developed, all applicable Federal and State regulations would apply to oil exploration, development, production, and transportation unless they were superseded by the legislation enacted by the Congress to open the 1002 area to leasing, and any implementing regulations. Currently more than 36 Federal and 5 State of Alaska laws, and 111 separate regulations found in 6 separate titles in the Code of Federal Regulations apply to oil and gas activities in Alaska. Some examples are the National Wildlife Refuge System Administration Act; Fish and Wildlife Coordination Act; Endangered Species Act; Clean Water Act; Coastal Zone Management Act; Alaska Native Claims Settlement Act; Alaska Environmental Conservation Act, Title 46; Alaska Oil Pollution Control Law; and Alaska Coastal Management Act. ~

~ Section 303 of ANILCA, which establishes additions to existing refuges, requires that the Arctic Refuge be managed "to fulfill the international treaty obligations of the United States with respect to fish and wildlife and their habitats * * *" [Section 303(2)(B)(ii)]. International treaties and agreements related to fish and wildlife species that are either resident, transient, or occasionally found in the 1002 area, include:

1. Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, October 12, 1940 (56 Stat. 1354, TS 081), Article VII, Migratory Birds.
2. Convention between the United States and Great Britain (for Canada) for the Protection of Migratory Birds (39 Stat. 1702; TS 628), as amended.
3. Convention with the Union of Soviet Socialist Republics on the Conservation of Migratory Birds and Their Environment (TIAS 9073).
4. Convention between the United States of America and Japan for the Protection of Birds and Their Environment (25 U.S.T. 3329, TIAS 7990).
5. Agreement on the Conservation of Polar Bears (TIAS 8409).
6. International Convention for the Regulation of Whaling, Whaling Convention Act of 1949 [16 U.S.C. 916-916(1)]. Article III of the act established the International Whaling Commission.
7. Convention on International Trade in Endangered Species of Wild Fauna and Flora (TIAS 8249).

During the early stages of preparing a preliminary draft report and detailed LEIS for departmental review, legal action was taken against the Department and the Fish and Wildlife Service by Trustees for Alaska and other environmental groups in Trustees for Alaska, et al, Civ. No. A85-551 (D. AK. Feb. 25, 1986). The plaintiffs contended that the Department's plans (that is, to circulate the report/LEIS for public comment concurrently with its submittal to Congress and to forward any comments received and the Department's responses subsequently) failed to fully comply with NEPA, and that the Department must provide an opportunity for public participation in preparation of the report/LEIS in advance of its submittal to Congress. The court ruled in favor of the plaintiffs. By court order dated February 25, 1986, the Department was directed to prepare both a draft and a final report/LEIS, and permit public review and comment on the draft report/LEIS. The court further directed that public meetings on the draft report/LEIS be held in Alaska and elsewhere and that the Department's responses to public comments be published locally before or at the time the final report/LEIS is submitted to the Congress. It was the position of the Department and the Service that a draft report/LEIS need not be circulated in advance and that a single detailed report/LEIS, as provided for in 40 CFR 1506.8(b)(2), fully complies with the requirements of NEPA.

Even though the government felt that the district court's ruling was incorrect, the Department of the Interior began the administrative process laid down by the district court because a final report/LEIS had already been delayed beyond the September 1986 deadline established by ANILCA. Subsequently, the Department unsuccessfully argued an appeal of the decision.

On November 24, 1986, the draft report/LEIS was made available for public review and comment. Originally scheduled to close January 23, 1987, the comment period was extended to February 6, 1987, at the request of the Governor of Alaska and others. Public meetings were held January 5, 1987, in Anchorage, Alaska, January 6 in Kaktovik, Alaska, and January 9 in Washington, D.C. Copies of the report/LEIS were sent to all Federal, State and local agencies with jurisdiction by law or special expertise; to the Government of Canada and the Yukon and Northwest Territories; to conservation organizations; to affected Native regional and village corporations and other organizations; and to the oil and gas industry.

During the comment period, 11,361 letters were received. The vast majority of these letters were generally a statement as to either (1) make the 1002 area available for oil and gas leasing, or (2) make the 1002 area a designated wilderness. Of those letters, 7,491 favored leasing and 3,707 favored wilderness designation. Letters were received from individuals in every State in the Union and Canada. Organizations, with such diverse positions as the Wilderness Society and the Alaska Oil and Gas Association, were responsible for 821 of the comments.

Substantive comments on the content of the report itself were received from 117 respondents. To facilitate analyses, the comments were broken down into the following categories: Federal governments, State and local governments, industry, organizations, and private individuals. Each of the 1,651 substantive comments was reviewed. General responses are contained in the "Summary of Consultation and Public Comments" section of this report and duplicated in the appendix to this report (v. 2). The report was modified as appropriate based on comments received. Throughout the report, the symbol ~ indicates (1) passages that have been significantly modified from the draft LEIS published in November 1986 and (2) new material.

~ DEPICTION OF CIVIL BOUNDARIES ~

"Civil boundaries are the limiting lines of jurisdictional authority for the various levels of government. These boundaries are shown on topographic quadrangle [and other] maps of the Geological Survey, but they are invariably derived from another source. The Survey does not make original boundary surveys, and the boundaries shown on the maps are not intended as conclusive evidence of land ownership or jurisdictional limits. Original boundary surveys executed by the appropriate organization provide the definitive evidence for settling boundary questions. Nevertheless, the boundaries shown on Survey quadrangle maps are often regarded by the general public and local authorities as representing authoritative locations. For this reason, boundaries are delineated on these maps as carefully as possible from available source documents; but the fact remains that the source documents, not the topographic maps, have primary legal significance with respect to boundaries." From Thompson (1981, p. 73).

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CHAPTER II

EXISTING ENVIRONMENT

INTRODUCTION

The existing environment (this chapter) and subsequent analysis of environmental consequences (Chapter VI) are described in terms of three components: physical, biological, and human.

PHYSICAL GEOGRAPHY AND PROCESSES

Physical Geography

The 1.55-million-acre 1002 area, located in the northernmost part of the Arctic Refuge between the Brooks

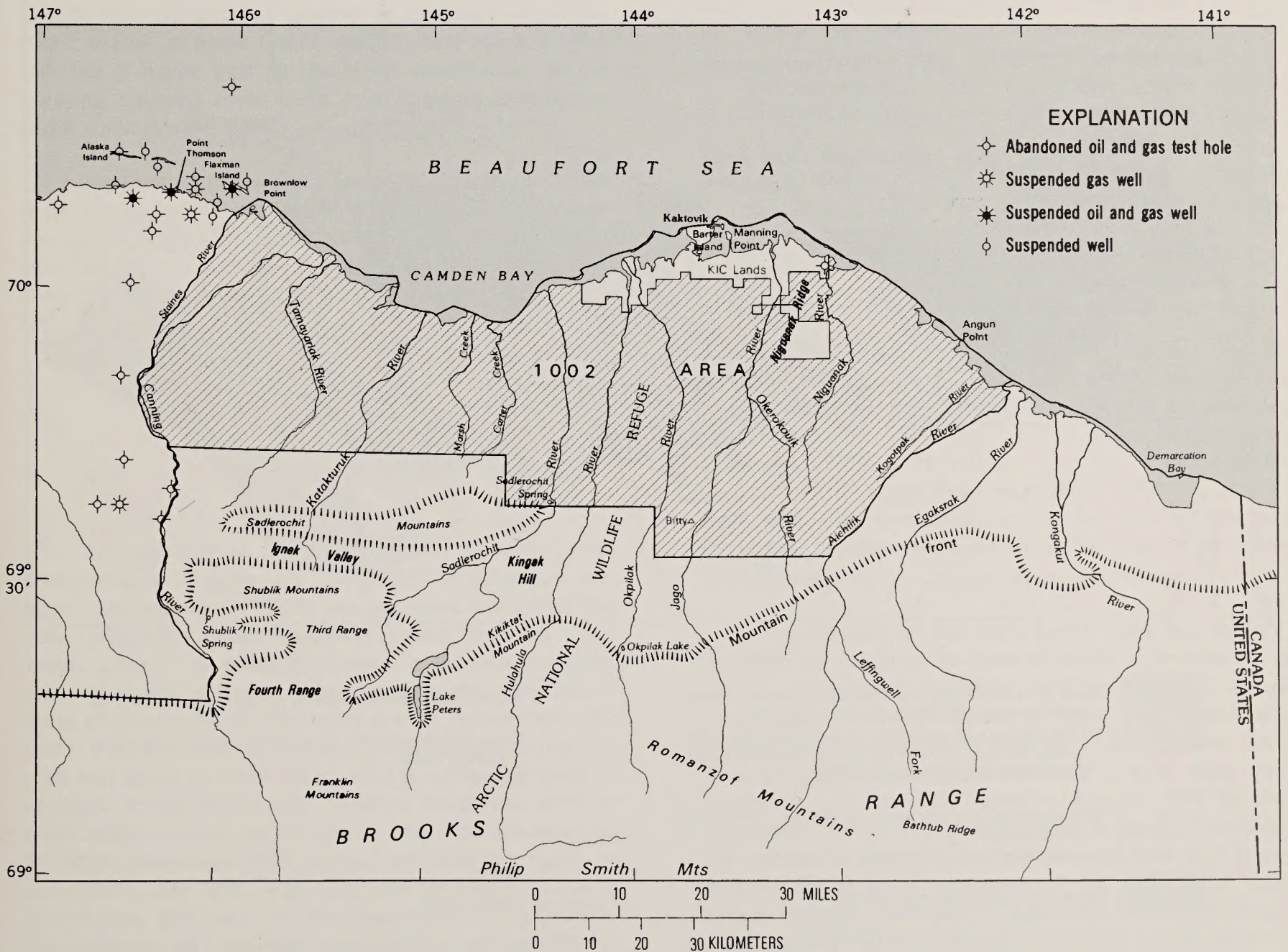


Figure II-1.--Map of northeastern Alaska showing the 1002 area and important nearby geographic features.

Range and the Beaufort Sea (fig. II-1), more than 250 miles above the Arctic Circle, is in the tundra-covered Arctic Coastal Plain Province, the only extension of the Interior Plains of North America in Alaska (Wahrhaftig, 1965). It is bounded on the north by the Beaufort Sea, and on the east by the northeast-flowing Aichilik River. The south boundary follows township lines and approximates the 1,000-foot elevation contour. The north-flowing Canning and Staines Rivers are the west boundary of the 1002 area and the Arctic Refuge. The 1002 area constitutes about 75 percent of the total coastal plain of the Arctic Refuge.

The 1002 area is about 104 miles in length at latitude 69°51'N. Maximum width is about 34 miles; minimum is 16 miles, south of Camden Bay. The area has 10 major northward-flowing rivers and 14 smaller rivers or named creeks. The majority of large rivers are braided; nearly all the creeks, even the many small unnamed ones, have extensive tributary systems.

Except for about 4 percent of scattered bedrock outcrops, the 1002 area is covered by a thin mantle of unconsolidated, frozen sediments of Cenozoic age that range in thickness from a few feet to about 100 feet (fig. II-2). The outcrops are mainly poorly consolidated Tertiary siltstone, mudstone, sandstone, and conglomerate in the Marsh Creek and middle Jago River areas; a few minor outcrops of Cretaceous and Jurassic shales along the lower Jago River; and Cretaceous and Jurassic shale, near the Niguanak River and in the Sadlerochit Spring area.

Oil seeps have been found in the Manning Point area, about 6 miles north of the 1002 area, and near Angun Point, within the 1002 area. Oil-stained sandstones crop out near the middle reaches of the Katakaturuk River; and oil-bearing sands and shales having an odor of oil crop out along the lower Jago River, about 10 miles south of Barter Island.

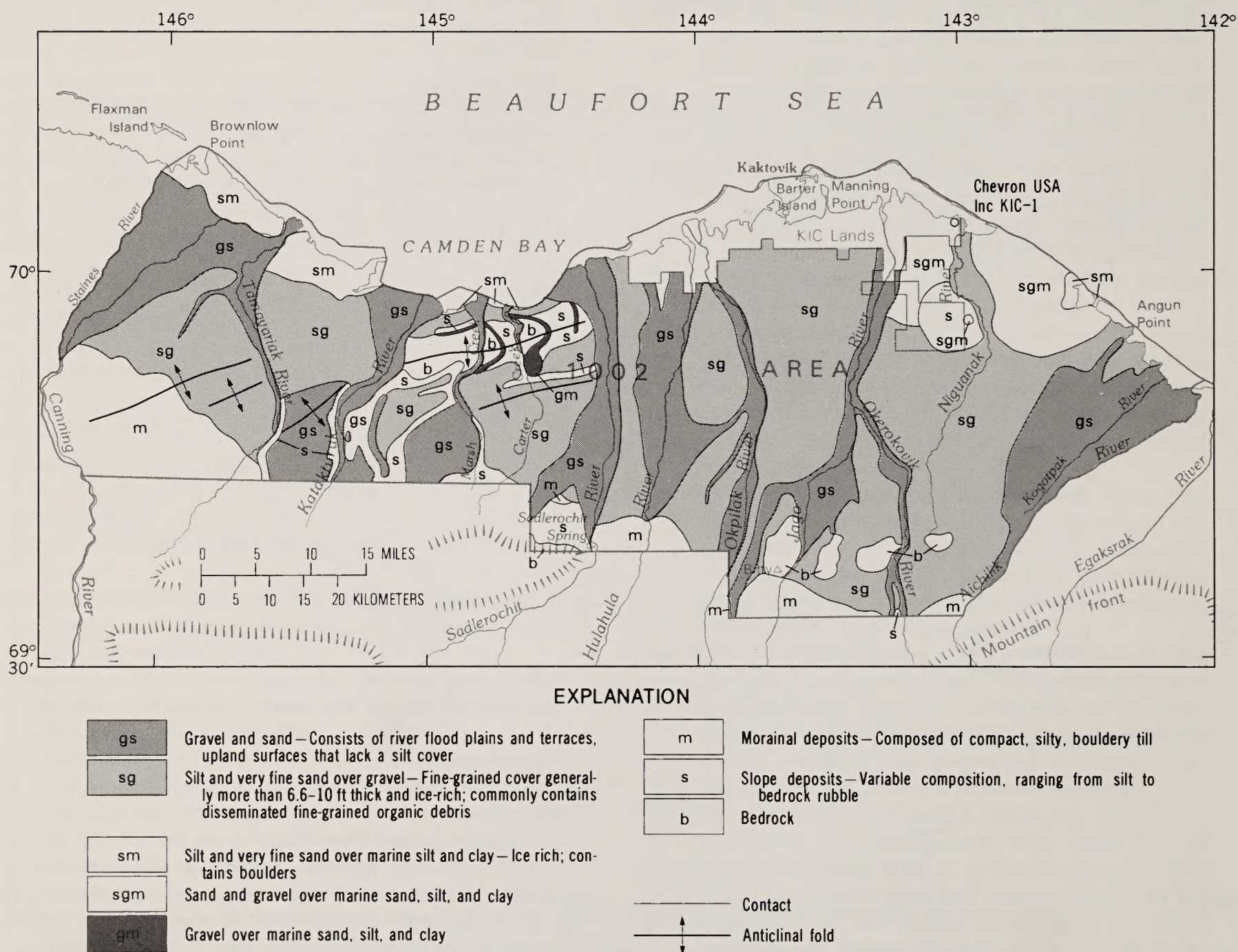


Figure II-2.—Generalized surficial deposits of the 1002 area. Map indicates surface materials only and not what could be borrowed for fill. Geology by Carter, Ferrians, and Galloway (1986).

Despite the arctic climate prevailing during the Pleistocene epoch, about 90 percent of the 1002 area is unglaciated. A large valley glacier extended northeastward approximately 12 miles into the area and probably about 7 miles along the Tamayariak River (southwest corner of 1002 area, map unit m on fig. II-2). Smaller valley glaciers extended about 4 miles into the area along the Hulahula River, just across the 1002 area boundary along the Jago River, and 2 miles along the Aichilik River. Glacial fluvial deposits and eolian materials are widespread, even in unglaciated areas.

The Beaufort Sea coastline, with its narrow beaches, is low-lying, gradually receding, and irregular in shape. It has numerous points, many offshore shoals, mudflats, spits, bars, and low-lying barrier islands behind which are shallow lagoons. The coast is punctuated by deltas, the most pronounced being those of the Canning, Hulahula-Okpilak, Jago, and Aichilik Rivers. Tides are small; the daily tide rarely exceeds 1 foot, and the maximum annual tide is less than 3 feet. Wind tides occasionally exceed the maximum lunar tides during periods of open water, particularly in late September-early October. The coast is characterized by bluffs commonly 4-5 feet high, locally as high as 25 feet. The 50-foot topographic contour is generally 2-3 miles inland, except at Barter Island, which is only about 3 miles wide but is higher than 50 feet in the central area. In the low-lying Canning River delta a comparable elevation is found about 8 miles inland.

Lagoons and bays are generally shallow, 3-12 feet deep, except for the greater-than-15-foot depths in Camden Bay, where the 18-foot depth contour is within about 200 yards of shore. Camden Bay offers the best reasonably deep, protected harborage along the coast of the 1002 area.

Climate

The climate of the 1002 area is arctic marine, characterized by extremely low winter temperatures and short, cool summers. Winds are persistent throughout the year. Blizzards occur frequently during the long, dark winter. Along the coast the climate is moderated by the sea and is less extreme. Meteorological data are limited; those of most value for this study are the marine data from Barter Island (Kaktovik) and the data from Umiat (to the west and about 75 miles inland, fig. I-1), which has more of an arctic continental climate. Umiat is the closest area for which inland climate records exist. The recorded minimum for Barter Island was -59°F in February 1950; the maximum was +78°F, July 1978. For Umiat the minimum was -65°F in February 1977 and the maximum +85°F in July 1977. The maximum and minimum temperatures last only briefly, often only minutes, and thus do not really affect either the environment or man's activities.

The average monthly temperatures, however, can markedly affect the environment and man's activities. From year to year, the average monthly temperatures, especially in winter, vary widely. At Barter Island, the average January temperature was +4.5°F in 1981, -21.8°F in 1983. At Umiat, the average January temperature was -11.2°F in 1982, -42.1°F in 1984. In summer, variations are less pronounced but more important because the accumulation of degree days above freezing (thaw index) greatly influences the depth of thaw in the soil and the rate of the melting of ice on water bodies. Some of the important average monthly temperature data and temperature-related thaw indices are tabulated below. The thaw indices show that usually approximately three times as much heat energy is received at the ground surface in the Umiat area during the summer months, but that the effect of an unusually warm summer can be relatively much greater at Barter Island.

Average temperatures and thaw index,
Barter Island and Umiat, 1976-84

	Barter Island	Umiat
Average temperature (°F):		
Coldest month.....	-33.1	-42.1
Warmest month.....	+42.9	+58.0
Thaw index (degree days above freezing):		
Maximum (summer).....	793	2183
Minimum (summer).....	456	1371
Average (summer).....	549	1671

~ In the Arctic, chill factor is more important than air temperature in evaluating temperature's effect. Strong winds coupled with cold temperatures produce chill temperatures sometimes colder than -100°F (-35°F and a 30-mph wind) (Selkregg, 1975). The average wind-chill factor at Barter Island during February 1984 was -80°F (-33.1°F and 15.5-mph wind). The combination of darkness and extreme cold in winter makes outdoor work difficult and often hazardous.~

Precipitation on the 1002 area is light but frequent, occurring as drizzle in the summer and as light snow in the winter. Published summaries indicate that the annual precipitation at Barter Island averages 6.28 inches and ranged from 2.93 inches in 1974 to 12.22 inches in 1955. Average summer precipitation is 0.52 inch in June, 1.01 inches in July, and 1.09 inches in August. The reported remaining 3.66 inches generally falls as snow throughout the rest of the year. Rainfall rarely exceeds 0.5 inch in any one day (three times in the last 15 years). On the North Slope, relative humidity is generally high during the summer--80-95 percent along the coast. During winter it falls to about 60 percent. Absolute humidity in winter is generally low, often 5-20 percent.

Snow can fall at any time in the 1002 area, although snowfall is greatest during September-November and January, with a lesser fall in May. Melting begins in late May and is largely completed in early June. Winds continually redistribute snowdrifts, baring inland ridgetops and drifting in the valleys, with drifts adjacent to stream cutbanks sometimes 20 feet deep. Higher microsites, such as tussock tops and high-center polygons, are frequently exposed, with hard-packed snow drifted between them. Felix and others (1987), traveling with the seismic crews in the spring of 1985, noted that the area west of the Sadlerochit River had significantly less snow than the eastern part of the 1002 area. According to numerous measurements taken throughout the 1002 area from January to May, average depths of snow actually accumulated on the ground were 12 inches in 1984 and 9 inches in 1985; measured depths ranged from 0 inches to at least 32 inches (Felix and others, 1987).

~ During 1955-84, the recorded average seasonal snowfall at Barter Island was 42.1 inches; the minimum was 19.9 inches in 1980-81, and the maximum 71.4 inches in 1961-62. Because the wind blows almost continuously, the snow crystals break up and pack much like fine sand; the snow often develops a density of about 0.4. As a result the actual winter precipitation may be about four times the 3.66 inches officially reported (Black, 1954). Wyoming-type snow gauges indicate that snowfall is somewhat less at Barter (an average of 5.4 inches of moisture over the last 6 years) than at Deadhorse (an average of 6.2 inches of moisture over the last 10 years) (George Clagett, Soil Conservation Service, unpublished data). ~

Easterly winds predominate most of the year. However, during January-April westerly winds are often associated with storms. The windiest month usually is January (mean 15.0 mph) and the calmest month, July (mean 10.7 mph). The peak gust (westerly) recorded at Barter Island was 75 mph in January 1980. Ice storms, or occasionally heavy rains, occur in October and January. The coast of the 1002 area can be subjected to storms rolling in from the Beaufort Sea during the open-water season. Even though Barter Island, the barrier islands, the shallow lagoons, and often nearby sea ice provide some shelter, these storms can severely erode the coastline.

In the 1002 area, particularly along the coastline and up to 5 miles inland, fog frequently reduces visibility. Along the coast, fog occurs most frequently during summer. At Barter Island, it reduces visibility to 6 miles or less about 27 percent of the time during May-September, reaching a maximum of 31.5 percent in August. Fog occurs an average of 10 percent of the time during the rest of the year. Inland, Umiat has fog about 15 percent of the time during September-May, and less than 10 percent during June-August.

Stratus clouds are prevalent in the Arctic during summer months, often persisting for weeks. The base of these clouds is often below 700 feet. At Barter Island and Umiat, clouds cover the sky 54 percent of the year.

In the winter, blowing snow and whiteouts can create conditions in which neither shadows, nor horizon, nor clouds are discernible, and depth perception and orientation are lost. At Barter Island, blowing snow reduces visibility to 6 miles or less about 10-22 percent of the winter. This is in addition to loss of visibility caused by fog.

At Barter Island, the sun is continuously above the horizon from May 15 to July 27, and continuously below the horizon from November 24 to January 17. In winter, when the sun is not more than 6° below the horizon, twilight permits many activities; at that latitude moonlight can be an important source of illumination. Twilight amounts to 6 or 7 hours in late November and is reduced to about 3 hours by December 21.

The arctic winter is characterized by frequent temperature inversions. Whereas the air temperature in the lower atmosphere normally decreases with increasing altitude, in a temperature inversion, colder air is overlain by a warmer layer of air. During the summer, surface temperatures are warmer and fewer inversions occur.

Freezeup normally begins in early to mid-September. Drier areas freeze first, sometimes cycling between freeze and thaw for several days. Wet tundra and ponds freeze over next, then lakes and rivers and protected shallow lagoons. In wet areas as long as 8 weeks may be required to completely freeze the "active layer" (that layer above the permafrost which annually freezes and thaws). A sudden cold snap, particularly if accompanied by wind, can freeze over all the areas within a day or two. Freezeup in the sea depends on late summer water temperatures, nearness of the ocean icepack, winds, and prevailing air temperatures. Generally, at least the nearshore sea is iced over by early to mid-October.

Thickness of the ice on the sea, lakes, and rivers is determined by numerous factors, including insulating value and thickness of the snow cover. Data from the Arctic coast indicate ice thicknesses of 2 feet in mid- to late November, 3 feet in mid- to late December, and 4 feet by mid- to late January. At the end of winter, the average maximum thickness of seasonal sea ice and fresh-water lake ice is about 6 feet. Near the cutbank of a river or a sea bluff where snowdrifts may be deep, the ice may be only 15-20 inches thick, whereas in the middle of the river it may be 6 feet thick. Similarly, should the winter temperatures be average or even mild and the snowpack be very light, the ice may be as much as 7.5-8 feet thick.

The ground is frozen until June. Rivers fed by melting snow in the foothills may start to flow as early as mid-May. Ponds, lakes, lagoons, and nearshore sea ice begin to melt in early June. Ice on deeper lakes may not completely melt until early to mid-July. Ice breakup in coastal lagoons and nearshore areas depends on runoff from the land, offshore grounding, and ocean currents. Where runoff is negligible, melting follows a pattern similar to that in deeper lakes. Melting of ice off river mouths is markedly different: fresh-water runoff begins in late May,

depositing river sediments on top of the ice; channels are often cut both on top and into bottom ice surfaces, and large holes may be cut through by river waters draining in a swirling, fast-cutting manner. Nearshore, land-fast sea ice often does not completely melt in place but floats away, beginning as early as late June.

Permafrost

Permafrost is defined as a thickness of soil or other superficial deposit, or even of bedrock, at a variable depth beneath the surface of the earth in which a temperature below freezing (32°F) has existed continuously for a long time (from 2 years to tens of thousands of years) (Muller, 1947). It may include soil, rock, minerals, interstitial and segregated ice (the latter as wedges or, less frequently, lenses), organic matter, or other materials both naturally occurring and those buried by man. Permafrost is often considered to be synonymous with "perennially frozen ground"; however, it need not be "frozen hard," because the material could contain water having an elevated salinity, as is often found in the National Petroleum Reserve in Alaska (NPRA), or could contain liquid hydrocarbons, such as oil seeps found in northern Alaska. Because of confining pressures, such as at the base of permafrost, the contained water could have a depressed freezing point. Or, because of low water content and particle-surface forces, the material could be unfrozen. The volume of ice in permafrost soils, particularly in the first few tens of feet below the ground surface, can be several times the volume of the mineral components; it can even approximate pure ice. At the other extreme some gravel may contain little, if any, ice.

Except for a small area at Sadlerochit Spring, which flows year round, the 1002 area is believed to be completely underlain by permafrost (Ferrians and others, 1969).

The minimal permafrost-temperature data available for Barter Island suggest an average permafrost temperature of +17.8°F to +15.8°F. Similar temperatures have been found in a series of shotholes extending from the coast inland 20 miles on the 1002 area (T. E. Osterkamp, oral communication to Max Brewer, 1986). Temperatures also vary with season and depth (Brewer, 1958a, fig. 3). Near Barrow permafrost temperatures range from about 31°F under the ocean at a depth of 70 feet, where annual change is negligible (Brewer, 1958a), to about 18.5°F beneath sandy unvegetated beaches, to about 15°F under dry tundra, to a minimum of about 13°F under very wet, low-centered polygonal tundra (Brewer, 1976). Similar temperatures and variations in temperature are believed to occur throughout the 1002 area.

The greatest reported thickness of permafrost in Alaska is about 2,250 feet near Prudhoe Bay; this thickness is believed to result from an anomalous thermal conductivity because of the unusually thick gravel in that area.

Permafrost thickness decreases markedly in all directions within a few miles. In the NPRA, the maximum known thickness is 1,330 feet, inland near Barrow (Brewer, 1955b). At Umiat the thickness ranges approximately from 700 to 960 feet. No wells have been drilled through the permafrost in the 1002 area; about 9 miles south of the southwest corner of the 1002 area, at the Exxon Canning River well, the measured thickness of permafrost is 928 feet. Thickness of the active layer in the 1002 area ranges from less than 1 foot to 5 feet and averages about 2 feet.

Depending on their depth and areal extent, lakes and rivers influence the shape of the permafrost table. Shallow lakes freeze to the bottom and are directly underlain by permafrost. Deep lakes (7+ feet deep) typically do not freeze to the bottom and consequently are underlain by a thaw bulb in the permafrost table (Brewer, 1958a, b). Shallow rivers and creeks freeze to the bottom, with the permafrost table usually a few inches to a few feet beneath. Some deeper rivers, such as the Canning, may have unfrozen pockets of water in deeper parts (7 feet or more at freezeup), but may be frozen to the bottom in shallower areas. Thus, the permafrost table beneath a river may be very irregular. The effects of surface features on distribution of permafrost are shown in figure II-3.

Studies of sea-water temperatures, seismic surveys, and boreholes in the Mackenzie Bay, Flaxman Island, Prudhoe Bay, Harrison Bay, and Barrow areas (figs. I-1, II-1) indicate that subsea permafrost occurs nearshore in the Beaufort Sea and probably extends in a thin layer out to water depths approximating 500 feet. Subsea temperatures range between the fresh-water freezing point and the sea-water freezing point, that is, from approximately 30.1°F at 15.0 feet below sea bottom in the Chukchi Sea off Barrow (Brewer, 1955a, 1958a) to 29.5°F at 22.3 feet in Harrison Bay off Atigaru Point, to 29.3°F at 17.7 feet in Prudhoe Bay off Reindeer Island (the latter two temperatures from Osterkamp and Harrison, 1985). Permafrost temperatures in the nearshore Beaufort Sea parallel mean annual bottom-water temperatures (Selkregg, 1975), approximately 31.1°F to 30.8°F for the Chukchi Sea, and 30.0°F to 29.7°F for the Beaufort Sea. Where the water in the shallow nearshore areas freezes to bottom, the permafrost temperatures decrease markedly, and the permafrost-temperature profiles are similar to those found on land (Osterkamp and Harrison, 1985). Farther east, eroded pingos, with the remains of their cores of ice, occur well offshore in Mackenzie Bay.

Few data are available concerning (1) amounts of ice in subsea sediments, (2) whether the ice is mostly interstitial, and (3) whether, at least nearshore, a significant portion of it is segregated as ice wedges. Information is also lacking regarding near-surface variability in ice content resulting from shoreline regression (about 3.3 feet per year), because of migrating spits, bars, and barrier islands, and because of inflow of warmer water from major rivers.

Permafrost-related stream data for the 1002 area are sparse. But data from the Shaviovik River, 35 miles west of the Arctic Refuge, are pertinent because the Shaviovik has many characteristics common to most rivers in the 1002 area except the Canning and Aichilik. The Shaviovik is shallow and has many bars, few potholes, heavy spring runoff, summer low- and high-water periods, and low water at freezeup. The average annual temperature in shallow sediments beneath the river (Brewer, 1958a) is about 5.4°F warmer than beneath the adjacent well-drained tundra, though well below the freezing point of fresh water. Measurements from the upper part of the geothermal profile beneath a narrow sand bar in midriver do not indicate an unfrozen zone in the river channel on either side of the bar in late winter. Temperature data from the 15- and 25-foot depths suggest that water is present in the channel at the time of freezeup, which delays the freezing process. Temperature profiles through and beneath shallow lakes are similar. Apparently, shallow rivers freeze to the bottom; sands and gravels in the river bottoms rest on permafrost and, by early November, are also frozen.

Ice wedges form when the upper few feet of ground, exposed to temperatures well below freezing, contracts and cracks, usually in a polygonal pattern. Hoarfrost forms in these cracks and is cemented by spring meltwater, leaving

a vertical stringer of ice. This ice limits expansion of warming permafrost in summer and the adjacent mineral soils are displaced upward; repeated cracking and widening of the ice wedges over many years eventually results in elevated ridges of material on each side of the wedges (Lachenbruch and others, 1962). Polygonal ground is the common surface feature in the 1002 area. Most polygons range in diameter from 30 to 200 feet and are easily recognized; some in the southern part of the 1002 area are masked by tussock-type tundra. Usually each polygon is separated from the adjacent polygons by ice wedges a few inches to several feet wide at the permafrost table. These ice wedges are 10-18 feet deep and are interconnected. Some small streams may have originated by the melting of a long series of ice wedges. Beaded streams, the beads located at the intersections of ice wedges, follow this pattern.

Most polygonal areas contain "low-centered" polygons, characterized at the outer edges by upthrust ridges that impede drainage from the polygon, giving the enclosed area a rice-paddy appearance.

Where slopes near streams or some lake banks allow drainage, "high-centered" polygons may occur. These polygons originated in the same manner as low-centered

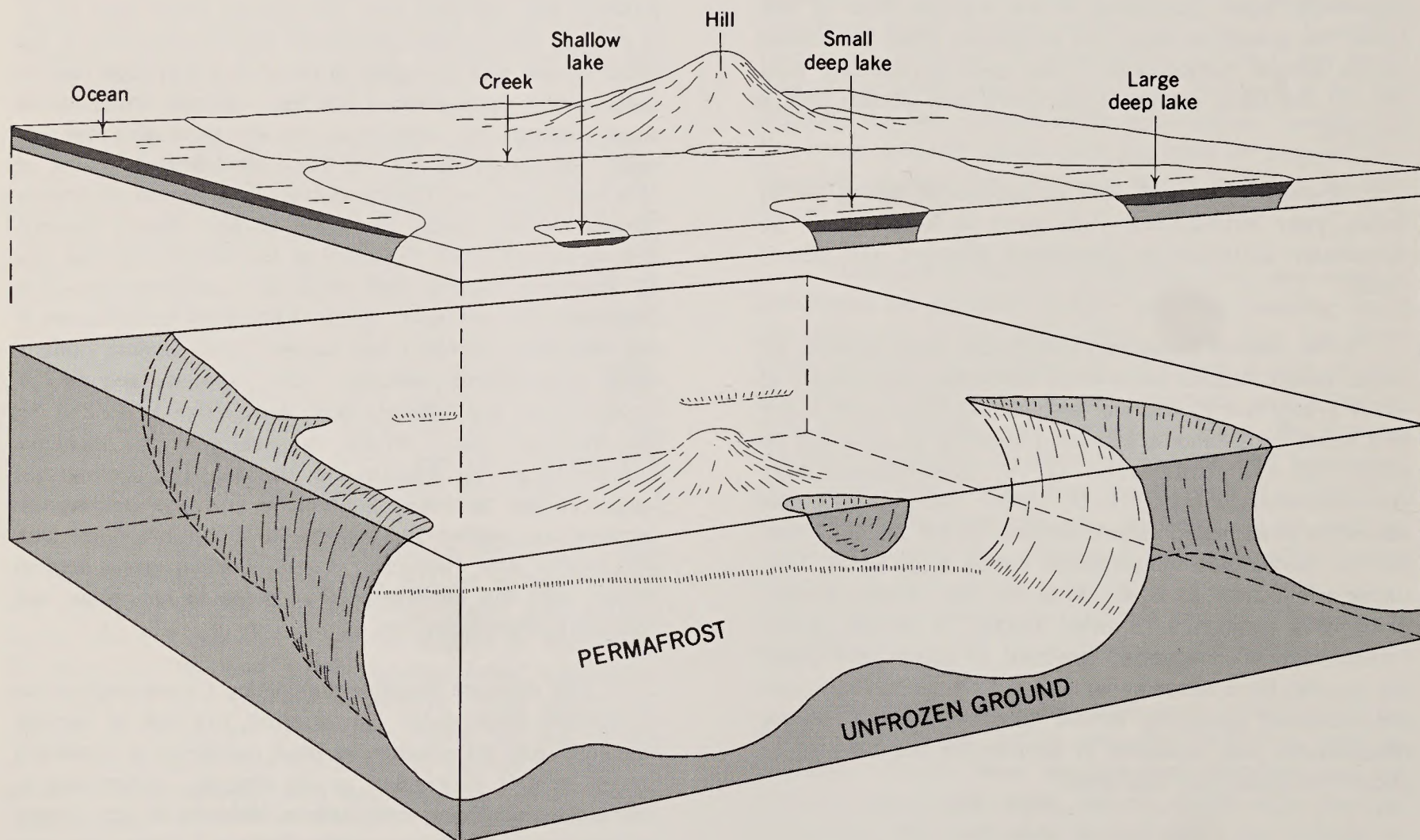


Figure II-3.--Schematic diagram showing the effect of surface features on the distribution of permafrost in the continuous permafrost zone. Modified from Lachenbruch, Brewer, Greene, and Marshall (1962).

polygons, but during exceptionally warm summers with deeper thaw, the tops of the ice wedges melt, water drains off, and the soil and tundra slump into the voids. The slumping, when continued over tens of years, produces ditches between the polygons, thus leaving the polygons as erosional remnants separated by partly filled voids.

Soils and Other Materials

The 1002 area is crossed by numerous north-flowing rivers that head in the glaciated mountains rising about 6-12 miles south of the area's boundary. Outwash plains, active flood plains, river terraces, and eolian deposits that resulted from winds during glaciation have covered much of the 1002 area with a thin mantle of unconsolidated, though frozen, sediments a few feet to about 100 feet thick.

The valleys of larger streams are underlain by large quantities of coarse sand and gravel (fig. 11-2, map unit gs). The Tamayariak, Katakturuk, Okpilak, Okerokovik, and Kogotpak Rivers, and especially the Canning, Sadlerochit, Hulahula, Jago, and Aichilik Rivers, are heavily braided and have extensive unvegetated gravel bars. Gravel also occurs in the south part of the 1002 area between the Canning River and Marsh Creek, along tops and flanks of ridges between the Katakturuk and Sadlerochit Rivers, and on spits and bars along the coastline. On the spits and bars the deposits range from fine to medium sandy gravel to sand. Granular deposits typically present in stream valleys range from coarse to medium sandy gravels containing cobbles, along the south boundary of the 1002 area. Downstream toward the Beaufort Sea the materials are progressively finer grained; in the deltaic areas they range from fine to medium sand. Sand dunes occur in the Canning, Hulahula-Okpilak, and Jago River deltas. Numerous sizable sandy shoals are prominent between the deltas of the Sadlerochit and Okpilak Rivers.

Soils are poorly developed and frequently water saturated, and can generally be classed as tundra soils, wetland soils, or sand dunes. They tend to be sticky and claylike and are in the beginning process of leaching, even in better drained areas, because of cold ground temperatures, the presence of permafrost, and the thinness of the "active layer." Polygonal patterning is well developed, although surface expression tends to be more pronounced adjacent to breaks in slope, especially those associated with drainage. A soils study in the valleys of the upper Okpilak and Jago Rivers (Brown and Tedrow, 1964) reported mineral uniformity in the soils, with quartz and feldspar each amounting to 40-50 percent in the sands, and heavy-mineral suites consisting of opaques, epidote, tourmaline, chlorite, actinolite, zircon, and minor amounts of other minerals. In view of the geomorphic history of the 1002 area, this type of mineral composition may be assumed to prevail there.

Except in the sand dunes, on ridgetops, and in unvegetated gravel areas, much of the 1002 area is covered by a 1- to 2-inch-thick organic mat of living vegetation

overlying a fibrous layer containing sand, silt, and small cobbles. That fibrous layer, in turn, overlies mineral soils of loam, silt, or sand. In well-drained areas thaw progresses to greater depths, and mineral soils near the base of the "active layer" may have a pronounced brownish appearance, owing to an accumulation of well-humified organic matter.

Water Resources

~ Despite the fact that 99 percent of the 1002 area is classified as wetlands, free water is limited and confined to the shallow zone above permafrost. The estimated 800- to 1,000-foot-thick impermeable permafrost precludes obtaining nonsaline water from within this zone. Although no wells have penetrated the permafrost zone in the 1002 area, any water that might occur beneath that zone probably would be brackish or at least moderately saline (Cederstrom and others, 1953; Hopkins and others, 1955; Brewer, 1958a, b, 1974; Williams, 1970). ~

Only a few large lakes are present in the 1002 area. A few shallow thaw lakes are found near the coast east of the Canning River delta, and east of the Hulahula-Okpilak River deltas, the latter being on Native land and outside the 1002 area. Except for two near the Canning delta, the lakes each cover less than 1 square mile; most have basins less than 7 feet deep and freeze to bottom by late winter.

Rapid spring snowmelt (10-14 days) causes water to accumulate on and flow over the river ice, fracturing and rapidly eroding it. Large chunks of ice break loose from the banks and bottoms of the river, and float downriver and may lodge in constricted areas, causing jams and extensive spring flooding, particularly in the deltas. Even if this does not occur, the rivers run very full because of the rapid snowmelt. Surface runoff often resembles sheetflow, because of the frozen ground. Suspended-sediment content is very high, perhaps 75 percent of annual transport (Walker, 1973), and riverbanks are severely eroded, higher cutbanks often being undercut. By the third or fourth week in June, rivers may subside to summer low-water stage. Late summer or fall rains rapidly bring the rivers to one or more flood stages. Warm weather may also cause the rapid rise of glacial rivers such as the Hulahula, Jago, and Okpilak. Low water prevails at the time of freezeup; by midwinter, most rivers go dry or freeze to bottom throughout most of their length, with the possible exception of a few basins or "potholes" near the mouth of the Canning and perhaps one or two other major rivers. Even early in the freezeup period, if the basins, or potholes, in the lower Canning are connected to the sea, water may be brackish because of sea-water intrusion. The Canning River has not been intensively studied. Long-term studies of the much-larger Colville River (having 3.5 times the length and approximately 11 times the drainage basin of the Canning) show that streamflow ceases during winter, and salt-water intrusions eventually reach as far as 58 km (35 miles) upstream (Walker, 1973).

~ Several springs occur along the north edge of the eastern Brooks Range. The largest of these is Sadlerochit Spring, just inside the south boundary of the 1002 area (fig. II-2). The spring flows year round; rate of discharge and water temperature are variable. Various discharges reported for the spring range from 21.2 cubic feet per second (cfs) (Craig and McCart, 1974) to 35-53 cfs (Craig, 1977), and 88.3 cfs (Williams, 1970). Warm temperatures of between 43°F (Craig and McCart, 1974) and 50-58°F (Craig, 1977) have been measured. ~

Numerous small springs have been found on rivers or in valleys south of the 1002 area where large icings have been observed (FEIS, 1983; Williams, 1970). Selected physical parameters have been measured for some springs (U.S. Fish and Wildlife Service, 1982). Icings (aufeis), especially those reported on rivers, require investigation to determine whether they result from discharge from true springs or from freezing of meltwater in areas having relatively steep gradient.

Turbidity from suspended sediment impairs water quality. Suspended-sediment concentrations are highest in the major streams and rivers during spring breakup and late summer and fall high-flow periods. During low-flow periods most streams are almost clear. However, the Canning, Hulahula, Okpilak, Jago, and Aichilik Rivers are somewhat turbid, owing to glacial inflow from tributaries. Some shallow lakes are turbid during summer, when wind and wave action disturb bottom sediments. Aside from periods of turbidity, the water in most rivers and lakes is virtually colorless. Tea-colored water, resulting from high concentrations of dissolved organic materials, is found in some smaller tundra streams and ponds.

~ Water quality of lakes and streams is lessened in winter because salts and dissolved organic material are excluded from the downward-growing ice. Dissolved oxygen levels can be depressed in the water that remains unfrozen owing to lack of aeration and the extended darkness that limits photosynthesis. The concentration of those materials depends on the ratio of water to ice as the ice thickens. Water in lakes and river pools that freezes nearly to the bottom is usually unpotable by late winter. During summer, however, dissolved oxygen (DO) is at or near saturation in lakes and streams. ~

Coliform-bacteria counts in lakes and ponds peak in early June because of the "washing action" of surface runoff. A secondary peak follows in mid- to late summer in areas where large concentrations of waterfowl arrive for molting and staging (Boyd and Boyd, 1963).

~ Ice in lagoons begins breakup in early June with an influx of fresh, silt-laden, relatively warm water from river and stream runoff and snowmelt. Much water initially flows over the top of the sea ice; silt, as thick as 4-6 inches and thinning seaward, has been deposited on the ice (Walker, 1973). Overflows can continue for several miles offshore, until meeting cracks in the ice. In shallow lagoons (less

than about 6 feet deep), the ice is often frozen to bottom, and water may puddle on top until the ice becomes free and floats. Moats form along the shore in early June, and by early to mid-July the lagoons are generally ice free. Freezepup begins in late September-early October. ~

By the time the lagoons are ice free, the influx of fresh water, coupled with some ocean current-flushing of hypersaline brines formed beneath the ice during the winter, drastically reduces salinity, often from as much as 32-33 parts per thousand (ppt) to <10 ppt. Salinity gradually increases during the balance of the summer owing to the influx of marine water through inlets and lowered discharges of fresh water.

Erosion and Mass Movement

Water and wind are the major shapers of the landscape because permafrost often is susceptible to erosion, as are the unconsolidated sediments supplied by earlier nearby glaciers, and exposed river channels, deltas, and offshore bars and barrier islands. Water causes the most erosion, especially during breakup. It flushes heavy sediment loads onto the sea ice; it undercuts high banks and ice-rich terraces, causing frozen blocks of soil to fall into the rivers; and it builds deltas and mudflats. Even though the results of lateral erosion are obvious in the multi-channel braiding of the major rivers, the gradients of streams crossing the 1002 area demonstrate the potential for vertical erosion. Gradients range from approximately 12 feet per mile on the Canning River, to 30 feet on the Hulahula and Aichilik, to 40 feet on the Katakaturuk and Sadlerochit, to about 50 feet per mile on Marsh Creek, which cuts through ridges of Tertiary sandstone and conglomerate.

Erosion along the coast and offshore during open water is less obvious. Leffingwell (1919) and MacCarthy (1953) suggested that bluffs and beaches erode approximately 3 feet per year; Leffingwell also reported an extreme shoreline recession rate of more than 30 feet per year. Wiseman and others (1973) measured 164 feet of bluff erosion on the east end of Pingok Island, west of Prudhoe Bay, during 3 weeks in 1972; this was also an extreme. Beach erosion varies greatly depending on storm intensity and nearness of pack ice from place-to-place and year-to-year along the entire Beaufort coast. Three to 6 feet of erosion per year may be the average. Erosion and deposition of eroded sands and gravel produces barrier-island or spit migration, especially where no vegetation is established. Such migration can introduce major variations in the temperature and thickness of subsea permafrost.

Thaw lakes elongated north-south are characteristic of the Arctic coastal plain farther west, but are not a pronounced feature in the 1002 area, where the few small lakes, except in the Canning-Tamayariak delta, are oriented either randomly or somewhat east-west. Because prevailing

winds are not greatly different, the general absence of north-south orientation suggests that the small thaw lakes found there are enlarged more by freezing and thawing than by mechanical (current) erosion.

Although precipitation is light, in summer the soils are frequently water-saturated because (1) evaporation rates are low, (2) the permafrost barrier prevents water loss to underground aquifers, and (3) irregularities in the permafrost table impede surface drainage. Despite the fact that saturation is usually conducive to solifluction and creep or slump in areas of steeper terrain, the surface impact of these processes is not widespread because of the generally coarse material involved. But once the surface is disturbed, these processes can become active, especially along coastal bluffs, terrace escarpments, lake margins, and ridge slopes. Locally along a stretch of the Katakaturuk River and near Marsh and Carter Creeks, landslides have occurred in weathered and poorly indurated Tertiary shale, siltstone, and sandstone. In all areas having any appreciable slope and exposed mineral soil, the soil migrates gradually downslope because of seasonal frost-jacking of individual soil grains.

Wind erosion is generally confined to the Canning, Hulahula, Okpilak, and Jago River deltas (where active dunes are found along their western banks) and to sandy river bluffs, exposed bars in braided rivers, and exposed spits and barrier islands. Though considered to be a summer phenomenon, wind erosion occurs during much of the year, in exposed areas along river bluffs and on barrier islands.

Seismicity

There has been some earthquake activity in the 1002 area, but historically the level of this activity is low. Earthquakes of magnitude 6 and larger on the Richter scale of intensity are potentially destructive; earthquakes of magnitude 5 could cause local damage. Since the mid-1960's epicenters of at least 6 shocks (5 of them offshore) having magnitude greater than 4.0 have been located within about 40 miles of the 1002 area between longitudes 143°W and 146°W. Uncertainties in epicenter locations are estimated to be about 25 miles.

No active faults are known through surface reconnaissance, but more detailed geologic investigations might reveal evidence of geologically recent movements. There is evidence of offshore seismic activity in the Beaufort Sea. The area historically is one of the least seismically active in the State (U.S. Department of the Interior, 1976, "Alaska" volume, map on p. 84).

Seismically active faults may occur; accordingly, earthquake potential within or adjacent to the 1002 area may be specified as a maximum expectable earthquake of magnitude 5.5 (U.S. Department of the Interior, 1976, "Alaska" volume, p. 86; Page and others, 1972). The maximum expectable earthquake is the largest earthquake that may reasonably be expected to occur. The probability of such an earthquake is low.

~ Air Quality ~

Human activity currently affects air quality in Arctic Alaska only near villages and the Prudhoe Bay/Kuparuk development area. Air quality is strongly dependent on local meteorological conditions and topography.

Strong temperature inversions on the coastal plain, particularly during the winter, often begin near ground level and hinder vertical air circulation and mixing. An inversion, if coupled with low, near-surface wind speeds, can produce prolonged stagnant air conditions, especially in areas having topographic obstructions such as hills and mountains. Although inversions are common in the 1002 area, persistent surface winds tend to prevent air stagnation.

In recent years Arctic haze has been reported, with the suggestion that some pollutants originate from the Ural Mountains (USSR) industrial complex (Rahn and Lowenthal, 1984). In April 1986, the National Oceanographic and Atmospheric Administration (NOAA) made one flight to investigate Arctic haze over Prudhoe Bay. At the time of the flight, there was a pervasive haze from several thousand feet to 20,000 feet in elevation, with clean air between that layer and the ground (Russell Schnell, NOAA, unpublished data). At higher altitudes, the sulfur dioxide, nitrous oxides, nitric acids, and ozone typically found in haze from the USSR were present. Lower levels of the haze were relatively clean, indicating that there was no contribution to Arctic haze from Prudhoe Bay activities.

Carbon-dioxide concentrations in the Arctic naturally show an annual cycle (Kelley and Weaver, 1966; NOAA, 1975). Concentrations are higher during the winter and under the snow (Kelley and Weaver, 1966); they are at their minimum in August, corresponding closely to the maximum vegetative bloom on the tundra.

Data on air quality in the 1002 area have not been acquired. However, because human activity is low, air quality in the 1002 area and the rest of the Arctic Refuge is expected to be generally very good, with ambient concentrations for air pollutants nearly at background levels. Current air pollutant concentrations are expected to result from a combination of natural sources and the residue of Arctic haze. Particulate matter (PM) can occur at high concentrations even in remote areas and in the absence of human activity due to windblown dust, soil or other surface cover.

Some data are available from Alaska's North Slope. Table II-1 summarizes monitoring data collected at Prudhoe Bay for a full year. The Environmental Protection Agency (EPA) reviewed these data and accepted them as meeting its siting, quality assurance, and other monitoring guidelines. During the data-collection period, North Slope production averaged about 1.5 million barrels per day. Arctic Refuge air quality is assumed to be at least as good as the ambient concentrations shown in table II-1.

BIOLOGICAL ENVIRONMENT

Terrestrial and Fresh-Water Environments

VEGETATION

The Arctic Refuge coastal plain is in the tundra region (Aleksandrova, 1980), where moderately wet to dry habitats are mostly continuously vegetated with low-growing (generally less than 1 foot high) plants such as sedges, grasses, mosses, lichens, small herbs, and dwarf shrubs. Taller shrubs are restricted to drainages and to south-facing slopes. Soils are underlain by permafrost having thaw depths of less than 6 inches in colder coastal areas to more than 36 inches in some riverbeds.

Early classifications categorizing the Arctic Refuge soils, landforms, vegetation, and land cover were developed from interpreted, color-infrared photographs (scale 1:60,000) and from a ground-truth reconnaissance survey in 1981. A preliminary Landsat land cover map based on high-altitude satellite photography and a derived simplification were produced in October 1981 (Walker and others, 1982). A second revised land-cover map was produced in 1984; field verification of that revision is ongoing. For example, verification shows that willows are not easily visible on Landsat photographs and may be underrepresented on current maps. The 17 cover classes identified in the 1002 area are one forest, three scrub, four herbaceous, four scarcely vegetated, and five other types (table II-2). Dominant vegetation within each 1002 area terrain type is discussed under that terrain type. Each vegetation type and correlations among classification systems are described in the final baseline report (Garner and Reynolds, 1986).

~ The FWS is currently examining the status of 30 plant taxa in Alaska that may be threatened or endangered with extinction. This list was published December 15, 1980 (45 FR 82480), with supplements published in 1983 (48 FR 53640) and 1985 (50 FR 39526). One candidate plant species, *Thlaspi arcticum*, occurs in the 1002 area (Murray, 1980b; Felix, Lipkin, and others, 1985). An endemic of the Alaska-Yukon region, *T. arcticum* is known from several widely disjunct areas. Within the Arctic Refuge scattered populations have been found in eight locations ranging from alpine sites on the upper Okpilak, Sadlerochit, and Canning Rivers to gravel bars, river terraces, and dry bluffs on the 1002 area along Marsh Creek and the Katakaturuk River (pl. 1A). It is also found in shrub tundra, dwarf heath, and occasionally in tussock tundra. At least three of these sites (Okpilak Lake, Katakaturuk River, and Marsh Creek) contain more than 100 plants each. This small, white to lilac-colored mustard plant flowers very early and is easily overlooked when past flowering. ~

Table II-1.--Ambient air concentrations measured at Prudhoe Bay, April 1979-March 1980, compared with national ambient air quality standards.

[Data from Crow and others (1981). Concentrations in micrograms/cubic meter. Monitoring data collected by Radian Corporation on behalf of ARCO. Alaska's ambient air quality standards are identical with the national standards, except that the State has an annual standard for total suspended particulates (TSP) at 60 ug/m³]

Pollu- tant	NAAQS		Measured concentration--			
	Time period	Concen- tration	Site 1		Site 2	
			High	2d high	High	2d high
NO ₂	Annual	100	4	--	3.5	--
CO.....	Annual	--	17.1	--	13.3	--
	8-hr	¹ 10,000	86	70	95	75
	1-hr	¹ 40,000	312	303	343	307
SO ₂	Annual	80	0.5	--	0.4	--
	24-hr	¹ 365	9	7		
	3-hr	¹ 1,300	25	18	13	11
O ₃	Annual	--	47.5	--	51.0	--
	1-hr	¹ 235	113	105	113	113
TSP.....	Annual	75	11.4	--	6.7	--
	24-hr+	¹ 260	³ 294	³ 119	³ 112	64
			^{1,2} 150+			

¹May be exceeded once per year.

²+260 ug/m³ is primary standard; 150 ug/m³ is secondary standard.

³Surface winds: at site 1, 45 mph, with gusts to 60 mph; at site 2, 47 mph.

Noise

Ambient noise levels over most of the 1002 area are low and result predominantly from natural sources or processes. During the winter, the principal sounds are those associated with the wind. Noise carries considerable distances (but not upwind), especially during calm, cold (-40°F) conditions because of the increased air density. Water noises, including those of wave action, occur during the summer. Manmade sounds are confined to village activities and to some isolated activities, such as hunting. Other manmade sources are aircraft, vehicle, and equipment operations.

Table II-2.--Landsat-identified vegetation cover classes and correlation with the U.S. Fish and Wildlife Service wetland classifications, 1002 area of the Arctic National Wildlife Refuge.

[Because of rounding, does not add to 100 percent. Class names were developed during mapping for Arctic National Wildlife Refuge comprehensive conservation plan and are not identical with earlier class names by D. A. Walker and others (1982). Wetland types from Cowardin and others (1979)]

Cover class	Acres	Percent	Wetlands	
			Classification	Acres
Deciduous forest tall scrub..	20	<0.1	Palustrine, forested, broad-leaved deciduous, temporarily flooded.	20
Total forest.....		<.1		
Dry prostrate dwarf scrub....	10,330	0.7	Non-wetland.	--
Moist prostrate dwarf scrub.	389,180	25.2	Palustrine, scrub-shrub, broad-leaved deciduous, saturated.	389,180
Mesic erect dwarf scrub	113,000	7.3	Palustrine, scrub-shrub, broad-leaved deciduous emergent, persistent, saturated.	113,000
Total scrub.....		33.2		
Very wet graminoid.....	3,910	0.3	Palustrine, emergent, permanently flooded.....	3,910
Wet graminoid.....	211,430	13.7	Palustrine, emergent, semipermanently flooded or seasonally flooded.	211,430
Moist/wet tundra complex....	238,660	15.4	Palustrine, emergent/scrub-shrub, broad-leaved deciduous, semipermanently flooded or seasonally flooded.	238,660
Moist graminoid tussock tundra.	465,350	30.1	Palustrine, emergent/scrub-shrub, broad-leaved deciduous, saturated.	465,350
Total herbaceous		59.5		
Scarcely vegetated scree	430	<0.1	Non-wetland.	--
Scarcely vegetated flood plain.	21,100	1.4	Palustrine, scrub-shrub, broad-leaved deciduous, temporarily flooded.	21,100
Barren flood plain.....	30,350	2.0	Riverine, unconsolidated shore, temporarily flooded or seasonally flooded.	30,350
Barren scree.....	230	<.1	Non-wetland.	--
Total scarcely vegetated areas.....		3.4		
Clear water (lakes, ponds, rivers).	17,290	1.1	Palustrine, open water, permanently flooded; or lacustrine, limnetic, open water, permanently flooded; or riverine, open water, permanently flooded.	17,290
Clouds-snow-ice	2,530	.2	Non-wetland.	--
Shallow water.....	450	<.1	Riverine, unconsolidated shore/open water.	450
Offshore water	40,880	2.6	Marine, subtidal, open water; or estuarine, subtidal, open water.	40,880
Shadow.....	1,160	.1	Not applicable.....	--
Total other.....		4.0		
TOTAL.....	1,546,300	100.1		1,531,620

WETLANDS

Approximately 99 percent (1.53 million acres) of the 1002 area is classified as wetland according to the FWS Classification of Wetlands and Deep-water Habitats of the U.S. (Cowardin and others, 1979) (table II-2). The FWS defines wetlands as lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have one of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soils; (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year. (Note: The FWS has prepared a preliminary list of hydrophytes and other plants occurring in wetlands of the United States in this classification system. The U.S. Soil Conservation Service has prepared a list of hydric soils for use in this classification system.)

Non-wetland, upland habitat in the 1002 area is generally restricted to sparsely vegetated sites outside active flood plains where the depth to permafrost is great enough to allow for well-drained soils. Areas having a dense vegetative cover are characterized by permafrost occurring at shallow depth due to the insulating effect of the organic mat. The soil in these areas remains saturated at or near the surface throughout most of the growing season. The vegetation is composed mainly of species typically adapted for life in saturated soil conditions.

TERRAIN TYPES

Six regionally significant terrain types (Walker and others, 1982) occur within the 1002 area. Five are discussed below. The sixth is the 131 square miles of ocean water within the 1002 boundary (5 percent).

FOOTHILLS

Foothills cover about 45 percent of the 1002 area. Between the Canning and Sadlerochit Rivers, an east-west distance of about 47 miles, low foothills rise from Camden Bay to the base of the Sadlerochit Mountains, 18-34 miles from the seacoast. The hills are as high as 1,250 feet and are interspersed with the drainages of the Tamayariak River, Katakturuk River, Marsh Creek, Carter Creek, Itkilyariak Creek, and the Sadlerochit River (fig. II-2). Barren gravel crops out on the crests of several hills, particularly near the Katakturuk River. East of the Sadlerochit River the foothills are farther from the coast.

Vegetation is dominated by sedges and tussock-forming sedges. Dwarf willow or birch are common but sparsely distributed. Mosses and lichens are important components of tundra vegetation. The main Landsat cover classes in the foothills are moist graminoid tussock tundra, mesic erect dwarf scrub, and moist prostrate dwarf scrub.

Frost-scars are often a component of tussock tundra and can constitute as much as 80 percent of the surface. Parallel and subparallel water tracks, commonly present, give the slopes a ribbed appearance. These water tracks are shallow, vegetated drainage channels that conduct snowmelt waters, and perhaps subsurface waters, during the thaw season. String bogs are often found in the channels, suggesting slow mass movement of the saturated soil. Vegetation in the water tracks is commonly dwarf shrubs, mainly dwarf birch and diamond-leaved willow.

RIVER FLOOD PLAINS

~ River environments (about 25 percent of the 1002 area) are among the most complex terrains. They include the barren deltas and braided channels of the larger rivers, the terraces and alluvial areas associated with old river channels, and the deltaic formations at the base of the foothills that possibly represent an ancient sea level (Institute of Arctic and Alpine Research, University of Colorado, unpublished data, 1982). Riverine systems consist of an active channel and one or more terraces. Most major rivers have braided channels about 0.6 to 2.5 miles wide. Most of the diamond-shaped islands between channels are inundated sporadically each year during snowmelt from late May to early June. These islands may be either unvegetated or vegetated. Unvegetated islands are subject to intensive water and ice scouring, and consist of gravel with little soil development. Vegetated islands are elevated slightly above the normal high water mark because of channel cutting and have a wide range of vegetation coverage, depending upon the extent and frequency of inundation. If present, soils consist of various thicknesses of silt loam, loam, and fine sandy loam over gravel and gravelly sands. ~

Land cover associated with river systems ranges from totally barren river gravels and mud to tundra indistinguishable from that in nonalluvial areas. The braided channels are subjected to intense disturbance during spring breakup. In addition, meandering streams and braided rivers are constantly changing their channels. Slightly more stable areas are often only partially vegetated but may contain a wide variety of taxa, making them among the most floristically rich sites in the region. Willows are common on vegetated gravel bars and may form extensive thickets; however, these thickets are not nearly so extensive as the riparian willow communities found farther west along the Sagavanirktok, Kuparuk, and Colville Rivers (fig. I-1). The relatively limited supply of riverine willow within the 1002 area is of significance to several wildlife species, as are riparian areas that are often snow-free earlier than other parts of the coastal plain. Smaller streams and quiet interchannel areas of the larger rivers have lush sedge and willow stands. Willow height varies with the amount of winter snow cover and summer temperature regime. Willows near the coast are mostly prostrate, whereas near the south boundary of the 1002 area, shrubs occasionally exceed 6 feet in height.

Land-cover categories for this area include clear water, barren and scarcely vegetated flood plain, wet graminoid, moist/wet tundra complex, dry prostrate dwarf scrub, and moist graminoid tussock tundra.

HILLY COASTAL PLAINS

Extensive areas of gently rolling topography cover more than 22 percent of the 1002 area. East of the Hulahula River and parallel to the coast are numerous slightly elevated ridges and depressions, most having less than 100 feet of relief. Flat, gently sloping (5 percent or less) interfluvial areas contain complexes of moist/wet tussock tundra associated with poorly developed flat-centered ice-wedge polygons. Ridges are mainly vegetated with moist prostrate dwarf scrub, moist graminoid tussock, and moist/wet tundra complex. Frost boils and hummocky ground are common. The depressions between ridges contain thaw-lakes of clear water and wet graminoid tundra. Stream drainages are well defined and have large expanses of relatively well drained terrain.

FLAT THAW-LAKE PLAINS

Thaw-lakes, drained lake basins, and expanses of low-centered ice-wedge polygons occur locally, primarily near the flat braided-river deltas, and cover 3 percent of the 1002 area. Thaw-lakes are generally elliptical, shallow (2 to 6 ft), and geomorphologically short-lived. They form as a result of disruption of the vegetation and organic cover of the polygonized tundra. Thaw of the ice-rich, near-surface materials and melting of ice wedges can result in a pool of standing water and development of a shallow pond that eventually becomes a thaw lake. The best examples of thaw-lake topography are: (1) at the confluence of the Canning and Tamayariak Rivers, (2) a narrow coastal belt extending east of the Canning and Tamayariak Rivers, and (3) a narrow zone between the delta of the Hulahula River and a point a few miles east of the Jago River.

Except for the vegetated basins of relatively recently drained lakes, some form of microrelief, mostly low-centered polygons and string bogs, is nearly always present on thaw-lake plains.

The microtopography of thaw-lake plains (elevation variations of only a few feet) is the major influence on the distribution of plant communities, and small elevation differences create distinct patterns of plant communities and soil associations (Wiggins, 1951; Cantlon, 1961; Britton, 1957; D. A. Walker, 1981). The perched water table is very close to the surface, or slightly above, for most of the area except for polygon rims and lake bluffs. The Landsat land-cover categories in the thaw-lake plains include moist/wet tundra complex, moist prostrate dwarf scrub, wet and very wet graminoid, clear water, dry prostrate dwarf scrub, and moist graminoid tussock.

MOUNTAINS

Alpine terrain represents only a few square miles in the 1002 area (about 0.05 percent), mostly above 1,970 feet elevation west of Sadlerochit Spring. Sadlerochit Spring is of special interest because poplar and other distinct plant species occur there (Murray, 1980a).

Vegetation communities in these areas are complex and are interspersed with unvegetated rocks and talus slopes. The character of the well-vegetated slopes varies considerably, but the more completely vegetated areas have extensive moss mats with numerous prostrate shrubs, such as mountain avens, prostrate willow, and small forbs. Limestone areas are of particular interest because unique assemblages of plants, such as the bryophytes associated with seeps in limestone, are present (Brown and Berg, 1980; Steere and Murray, 1976). The main land-cover classes include barren and scarcely vegetated scree and dry prostrate dwarf scrub.

~ Special Terrestrial and Aquatic Environments ~

Within the 1002 area, four distinct areas have been identified for their special natural characteristics.

SADLEROCHIT SPRING SPECIAL AREA

~ Sadlerochit Spring and the immediate area (640 acres), in the southern part of the 1002 area west of the Sadlerochit River (pl. 1A), have been nominated as a National Natural Landmark (Bliss and Gustafson, 1981). The National Natural Landmark program was established to encourage the preservation of areas illustrating the diverse ecological and geologic character of the United States. Areas qualifying as National Natural Landmarks must be free of disturbance and capable of retaining and perpetuating their inherent natural qualities, as well as having exceptional scientific research and education values. Sadlerochit Spring is unique on the coastal plain because of its large discharge and almost constant temperature, which maintains an open channel for nearly 5 miles downstream during the coldest part of the year. Located on the coastal plain near the foothills, it is one of the largest perennial springs on the North Slope of Alaska. Reported discharges range from 21.2 to 88.3 cfs (Craig and McCart, 1974; Craig, 1977; Williams, 1970); its waters are warm (50°-58°F) and support a dense population of tiny organisms (macro-invertebrates) (400 to 500 per cubic foot) and populations of arctic char and arctic grayling (Craig, 1977; Craig and McCart, 1974; Williams, 1970). Sadlerochit Spring is a wintering area for fish (pl. 1B); such places are extremely limited on the 1002 area and are generally associated with the larger springs. Several plant and bird species not found anywhere else this far north are associated with this spring. Muskoxen use the area throughout the year. ~

The Sadlerochit Spring Special Area, as designated by regulations for exploration in the 1002 area, encompasses an approximately 4,000-acre area within 1/2 mile of the spring outlet and extends 1/4 mile on each side of the river downstream 5 miles to the aufeis field [50 CFR 37.32(g)]. The spring and its surrounding area have been identified as a special area primarily for the unusual plant communities and associated diverse wildlife (pl. 1A). Because of the spring's special values, exploration activities have been prohibited. The Sadlerochit Spring area is used for traditional subsistence harvest, particularly in winter, when people from Kaktovik camp at the spring and hunt and fish (Jacobson and Wentworth, 1982).

~ KONGAKUT RIVER--BEAUFORT LAGOON ~

An area of approximately 133,700 acres at the mouth of the Kongakut River, and extending along the coast from Demarcation Bay to Angun Lagoon, was identified as a potential National Natural Landmark (Koranda and Evans, 1975). Most of this proposed National Natural Landmark lies east of the 1002 area within the Arctic Refuge Wilderness. However, about 25,000 acres extends into the extreme northeast corner of the 1002 area. The area was recommended for designation as a National Natural Landmark because it contains:

1. An offshore bar and lagoon ecosystem which supports a relatively diverse marine biota and terrestrial biota using the area for nesting and migration rests.
2. An Arctic river which flows from the mountain front and enters the lagoon ecosystem, perpetuating the marine conditions of fresh water throughout most of the summer, and the presence of spruce trees in the upper course of the river, accompanied by elements of the boreal flora (Koranda and Evans, 1975).

~ ANGUN PLAINS ~

On the eastern end of the 1002 area, one complete township (T. 6 N., R. 38 E.) was identified as a potential National Natural Landmark primarily because of its special geologic features. The area serves as " * * * a good example of the glacial gravel outwash plains found near the areas of maximum Pleistocene glaciation" (Detterman, 1974).

~ JAGO RIVER ~

It has been proposed (Viereck and Zasada, 1972) that parts of the Jago River drainage be included in a system of "Ecological Reserves" in Alaska. The area contains a complete array of tundra and flood-plain vegetation types and provides habitat for a cross-section of all Arctic Slope wildlife species. The drainage contains a glacier and outwash, an arctic river system, delta sand dunes, an arctic coastal lagoon system, small tundra lakes and streams, and offshore islands. The proposals

suggested that specific areas for inclusion in the natural area system (that is, Research Natural Area) be selected by refuge personnel. No selections have been made.

Coastal and Marine Environment

Coastal-marine habitats in the 1002 area include offshore, nearshore, open coast, delta, and barrier island/lagoon-mainland shore areas, and those parts of the coastal uplands directly affected by storm surges and marine saline intrusions. These areas provide essential shelter, staging areas, and other life supports to resident and migratory fish and wildlife populations. Beaches, spits, and bars occur throughout the area. Although permafrost probably underlies these sites, it does not enter into the soil taxonomy. The inland extent of coastal habitats, biologically defined as the maximum inland reach of storm surges, is identified in many areas by the "strandline" of large drift logs and other debris, and by the extent to which salt spray and ingress of saline water affects the vegetative cover along the coast.

The North Slope Borough (NSB) Coastal Management boundary includes State lands within the 3-nautical-mile offshore territorial limit, extending inland approximately 25 miles, and State lands up certain streams to include anadromous fish spawning and fish overwintering habitat. The NSB developed a Coastal Management Program approved by the State on April 17, 1985, under the framework of the Federal Coastal Zone Management Act and the Alaska Coastal Management Act of 1977 (AS 44.19.891-894 and 46.40). However, the Federal Office of Ocean and Coastal Resource Management in the Development of Commerce denied approval on August 8, 1986. The Program was not approved because the Federal officials felt it did not provide adequate consideration of the national interest in energy facility siting as required by Section 306(c)(8) of the Coastal Zone Management Act. It did not provide an adequate balance between energy development and subsistence use, but instead unduly restricted energy facility siting.

Concurrent with the Coastal Management Program, the NSB initiated planning programs and sociocultural and economic studies. The NSB Comprehensive Plan and Land Management Regulations became effective January 1, 1983.

Under section 307(c)1 of the Federal Coastal Zone Management Act, Federal activities directly affecting the coastal zone must be consistent with the approved State Coastal Management local program to the " * * * maximum extent practicable." The NSB Coastal Management Plan noted that the Hulahula, Okpilak, and Aichilik Rivers within the 1002 area had values warranting special attention (NSB, 1984a).

Goals of the State-approved NSB Coastal Management Program relevant to government and economic activities in the area are described at the end of this chapter under "State and Local Political and Economic Systems." Most applicable to the coastal and marine environment is the program goal of protecting the natural environment and its capacity to support subsistence activities.

~ During the recent seismic and surface geologic exploration programs on the 1002 area, the FWS consulted closely with the State of Alaska, Division of Governmental Coordination, to ensure that the exploration proposals were consistent with the State's Coastal Management Program. If development is allowed on the 1002 area, the FWS would continue this coordination. The State would review all projects and development plans for consistency with coastal zone management standards. ~

Fish and Wildlife Resources

The fish and wildlife on the 1002 area are discussed by species, in five categories: terrestrial mammals, marine mammals, birds, fish, and threatened and endangered species.

TERRESTRIAL MAMMALS

~ CARIBOU ~

The Porcupine and part of the Central Arctic caribou herds are found within the 1002 area during various times of the year. Each herd has specific distributions, movement patterns, and herd dynamics.

The Porcupine caribou herd (PCH) is an international resource, estimated by the Alaska Department of Fish and Game (ADF&G) to contain 180,000 animals in 1986. The herd is increasing and is the sixth largest herd in North America (Whitten, 1987). The Western Arctic herd (population 220,000-240,000) is the only herd in Alaska larger than the PCH (Williams and Heard, 1986). Earlier estimates of the PCH populations were as low as 101,000 (LeResche, 1972). The most current photocensus of the herd was for 135,000 animals in 1983 (Whitten, 1984); more recent estimates are projections using productivity and mortality estimates. The lower levels of earlier estimates may reflect either a truly smaller population or less accurate or less complete survey techniques, or a combination of these factors. Caribou populations fluctuate unpredictably over the long term. The long-term maximum and minimum population of the PCH and the carrying capacity of the area are unknown.

The PCH ranges over 96,100 square miles of northeast Alaska and northwest Canada (figs. II-4 and II-5), and constitutes the largest population of large mammals shared by the two nations.

The traditional calving grounds of the PCH extend throughout the Arctic foothills and coastal plain from the Canning River in Alaska to the Babbage River in Canada. Including the entire 1002 area, the calving grounds encompass nearly 8.9 million acres (pl. 2A and fig. II-5). From year-to-year, the distribution of caribou on these calving grounds varies considerably, with most calving usually taking place in the area between the Hulahula River and the Canadian border (fig. II-5).

Spring migrations to the calving grounds start in April-May from winter ranges, which are usually south of the Continental Divide in Alaska and in central Yukon Territory and adjacent Northwest Territories in Canada (fig. II-4). Timing and routes of PCH migrations vary annually depending on winter distributions, snow conditions, and the onset of spring weather. Most PCH caribou migrate from Canada, moving westward along the northern foothills of the Brooks Range to reach their calving grounds. In some years caribou also pass through the first snow-free mountain valleys east of the Aichilik River in Alaska. As spring progresses, caribou in the foothills spread northward along a broad front, mostly following the major river corridors and associated terraces where snowmelt has advanced.

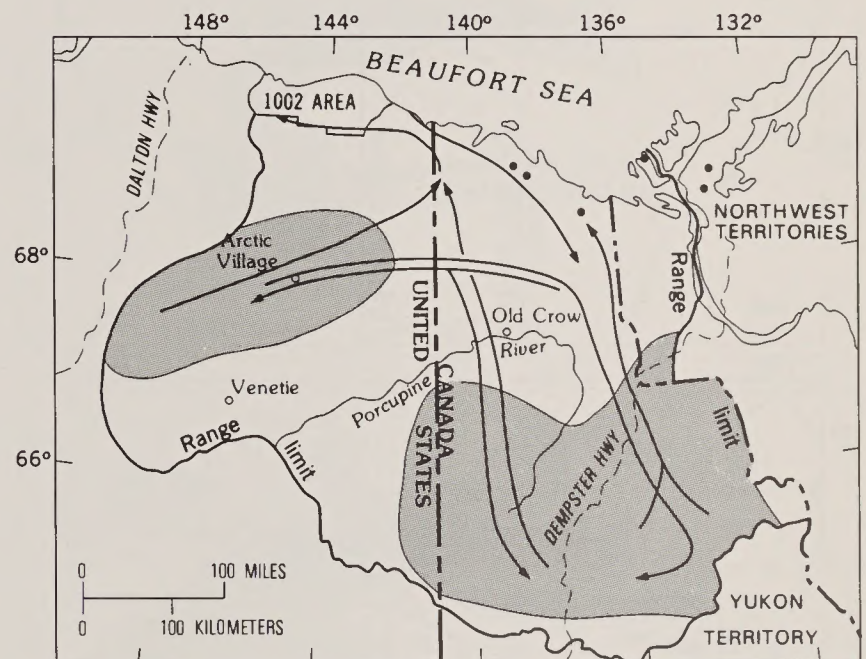


Figure II-4.--General range, migration routes (arrows), and winter range (shaded) of the Porcupine caribou herd. Solid circles indicate exploratory drill holes.

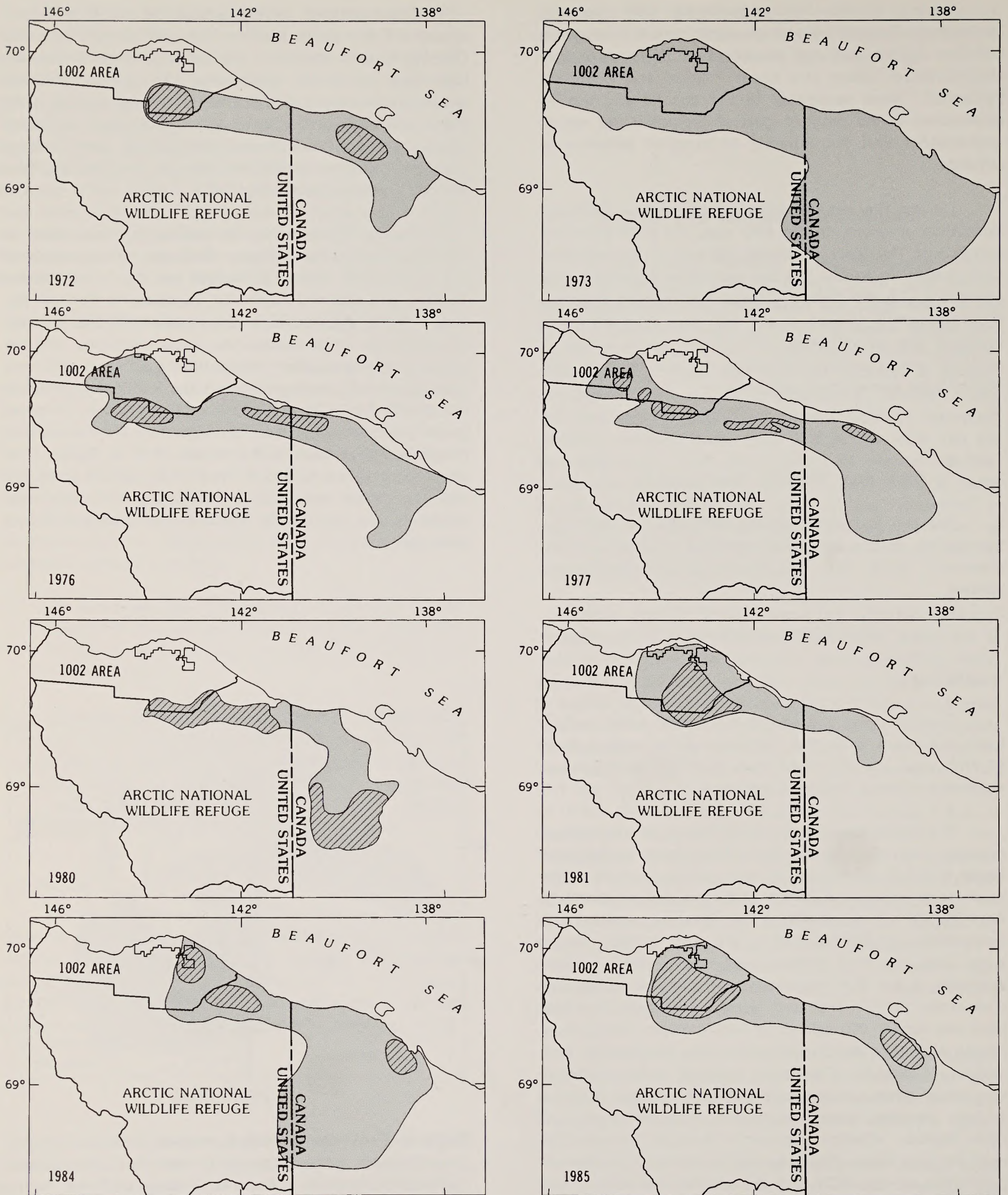
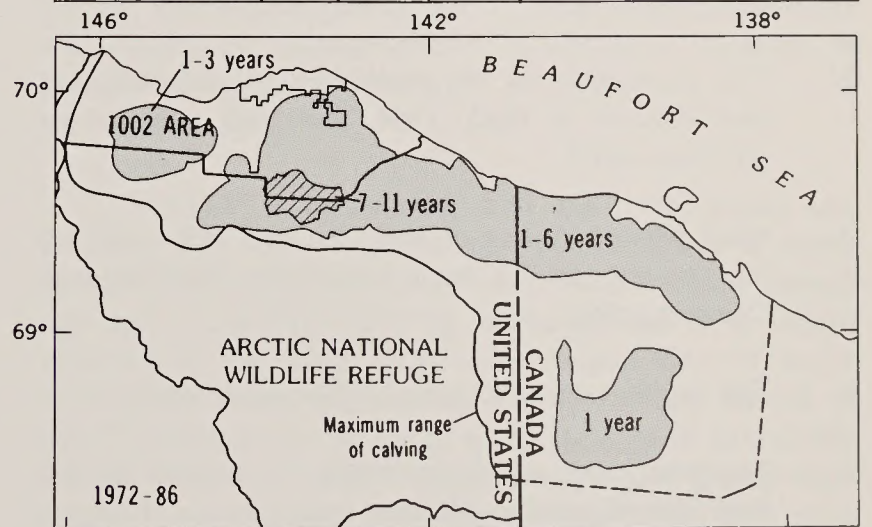
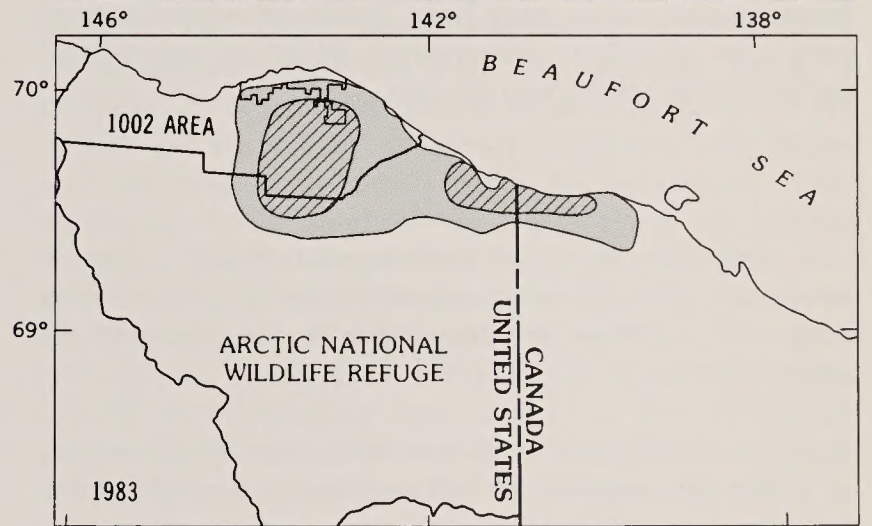
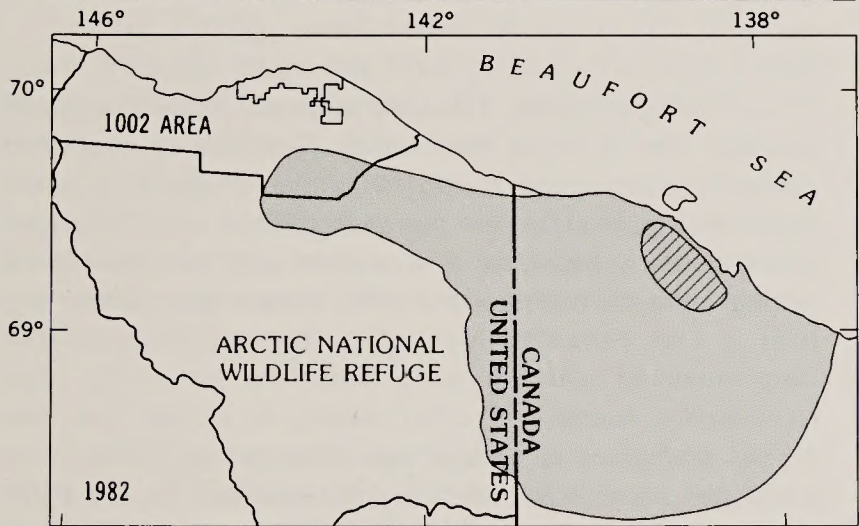
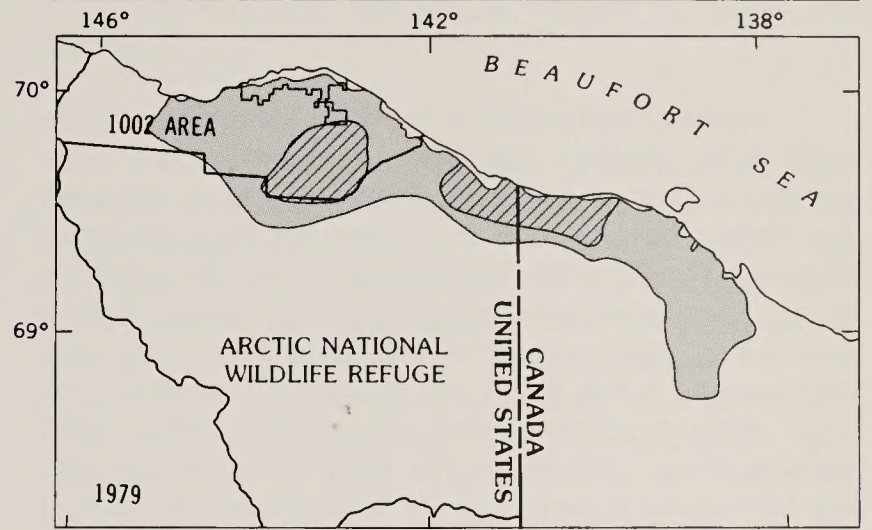
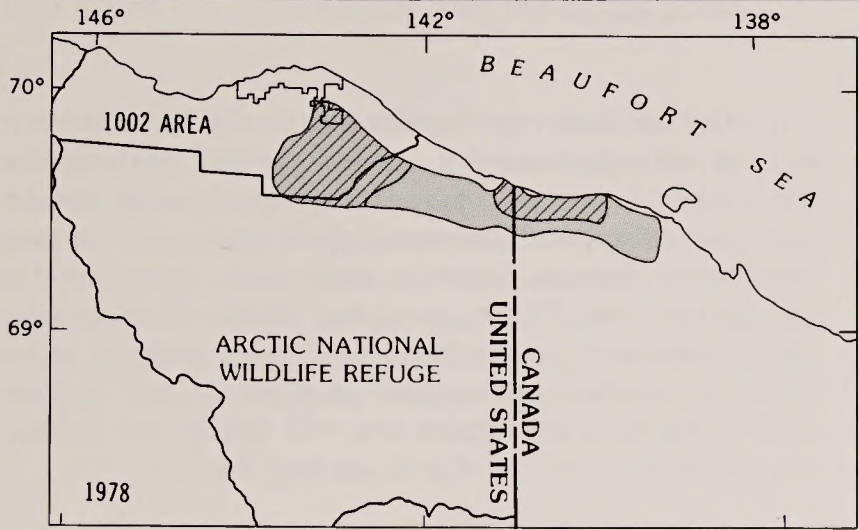
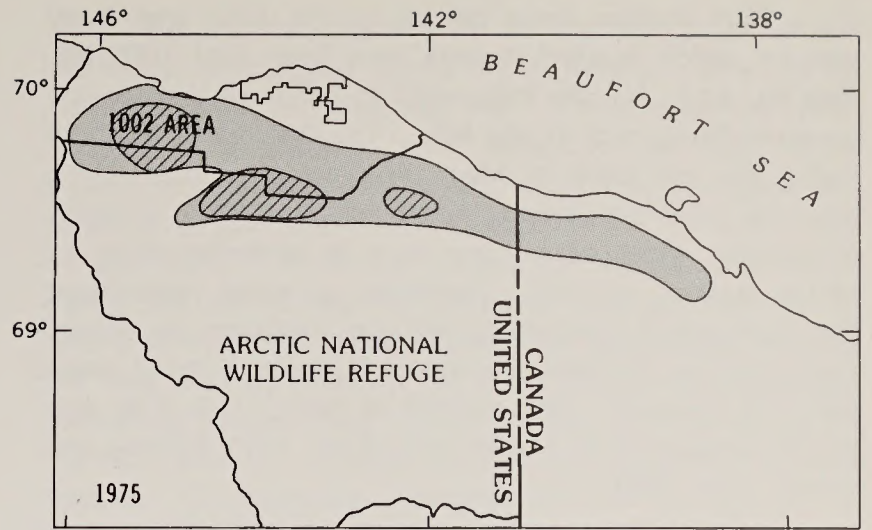
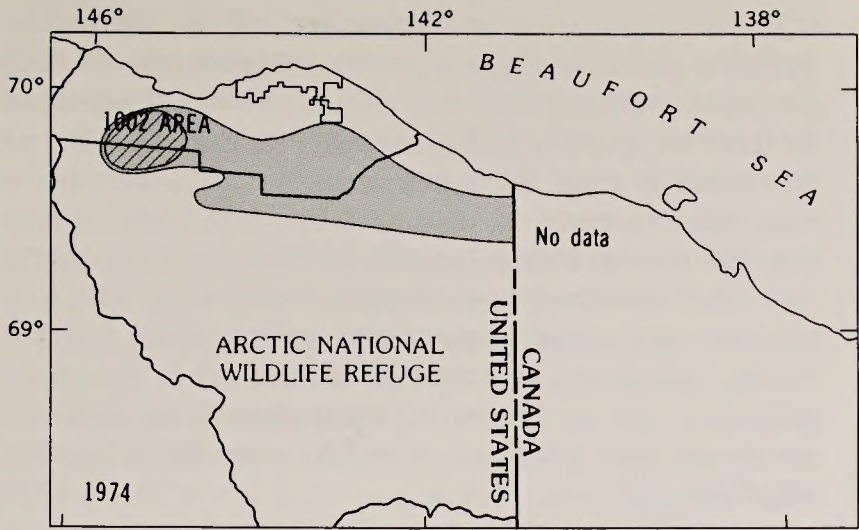


Figure II-5.--Total calving areas and concentrated areas of the Porcupine caribou herd by year for 1972-86 (15 maps) and composite map of all concentrated calving areas for 1972-86, including maximum extent of scattered calving (1 map).



EXPLANATION



Concentrated calving area



Total calving area

PCH caribou have calved on the 1002 area every year for which detailed records have been kept (1972-86). (See fig. II-5.) Usually they begin to arrive on their calving grounds during mid- to late May. The first calves are born during the last week of May; peak calving occurs during June 4-8. Although calving has been observed in a variety of terrains, most calves are born in snow-free areas of sedge tussock uplands. Vegetation provides camouflage; this background presumably reduces predation on calves. Also, predator densities are apparently lower in these areas and, subsequently, calf survival is better (U.S. Fish and Wildlife Service, 1982; Mauer and others, 1983; Whitten and others, 1984, 1985).

Detailed observations of the PCH calving areas were made during 1972-86. The earlier information, 1972-77, was gathered as part of the Arctic Gas studies for a proposed gas pipeline from Prudhoe Bay across the Arctic Refuge to Canada. The Canadian Wildlife Service and Yukon Wildlife Branch conducted studies of the PCH during 1978-81 because of their concerns with potential oil and gas developments in the Yukon and Northwest Territories. The most detailed studies were part of the section 1002 baseline study, 1981-85, by the FWS in cooperation with the ADF&G and Canadian wildlife biologists. As a result of these studies, areas have been delineated where caribou were most abundant (concentration areas) at the peak of calving activity (pl. 2A and fig. II-5).

Densities for entire calving concentration areas in each year, 1983-85, were calculated using data collected from radio-collared females and with the following six assumptions.

1. The distribution of radio-collared adult female caribou are representative of that segment of the herd at the time of calving.
2. The population of the PCH was 135,000, 149,000, and 165,000 in 1983, 1984, and 1985, respectively (Whitten, 1987).
3. Adult females (those at least 3 years old) make up 35 percent of the total population (Whitten and Cameron, 1981).
4. The natality rate is 80 percent (Bergerud, 1980).
5. Yearlings make up approximately 12 percent of the total PCH population (Whitten and Cameron, 1981).
6. One-third of the yearlings are on the calving grounds at calving time; up to 60 percent of these are in peripheral areas and the remaining 40 percent in concentration areas (Whitten and others, 1984; FWS, unpublished data).

Calculated densities ranged from 46 to 128 caribou (including cows, calves, and yearlings)/square mile for each calving concentration area, 1983-85 (FWS, unpublished data). Prior to 1983, caribou densities in areas identified as concentration areas are largely unknown. However, limited measurements made in 1972 near the Jago River showed densities ranging from 8.2 to 375 caribou/square mile during June 10-17 (McCourt and others, 1974). As the difference between high density concentrated calving areas, and low density peripheral or scattered calving areas is readily apparent, use of the term "concentrated" by previous observers was assumed to reflect densities of similar magnitude.

On the basis of intensive counts using helicopters, as well as radio-telemetry surveys, calving concentration areas were found to contain predominantly adult females and their calves, and peripheral areas had proportionately more barren females, yearlings, and young males (Whitten and others, 1984; FWS, unpublished data). Consequently, the concentrated calving areas have been deemed to be the most important calving areas because (1) they support most of the parturient females and their calves, and (2) they are the areas having the highest caribou densities.

The open rolling hills and adjacent thaw-lake plains between the Hulahula and Aichilik Rivers have supported calving concentrations during 10 of the 15 years, 1972-86. Precise boundaries of concentrations vary annually. However, there has been a consistent and continued focus on this area by calving caribou for several generations (fig. II-5). The repeated use of certain portions of the concentrated calving area and the generally high reproductive success of cows calving in or near the area implies preference and value over other areas. Thus, these areas are considered valuable and important to the PCH. Of the 3 million acres identified as concentrated calving areas, 828,000 acres (28 percent) are within the 1002 area.

During years when snowmelt on the coastal plain is early, a broad zone north of the foothills is used for calving. In such years calving concentrations tend to be more northerly and scattered calving extends to the coast. In years when calving is skewed to the east, usually due to late snowmelt on the coastal plain and/or deep snow on migration routes, there has been a distinct, consistent westward movement to the coastal plain after calving. The annual variability in concentrated calving areas is illustrated in figure II-5. Directional movement lessens once caribou have reached the calving grounds. During and immediately after calving, foraging caribou use vegetated riparian habitats as well as tussock uplands. Riparian areas (pl. 2A) are used as travel corridors and feeding areas in both spring and summer (Garner and Reynolds, 1986).

In all years of study, 1972-86, a majority of the PCH used the 1002 area for calving and/or postcalving activities. Recently the percentage of PCH cows using the 1002 area for calving was estimated to be 74 percent in 1983, 35 percent in 1984, 82 percent in 1985, and 24 percent in 1986. The 1983-86 estimates were extrapolated from locational data from radio-collared cows (Garner and Reynolds, 1984, 1985, 1987; FWS, unpublished data). In 1984, 38 percent of the PCH calved adjacent to the 1002 area, east of the Aichilik River, then within a week moved with their calves onto the 1002 area to join the 35 percent that calved on the area. Although only 24 percent of the PCH calved in the 1002 area in 1986, essentially the entire herd moved into the 1002 area after the calving period.

In Arctic areas, caribou reproduction is highly synchronous. The majority of calving occurs within a 2- to 3-week period, when a single calf is born to most adult females (3 years old). Caribou calves are precocious, able to stand and nurse within 1 hour after birth. They are capable of travel with adults within a week. The first 24 hours of life is critical, when a behavioral bond is formed between the calf and its mother (Bergerud, 1974; Lent, 1964).

After calving, small bands of cows with newborn calves gradually merge into larger groups. Yearlings, barren females, and bulls occupying the southern and eastern periphery of the calving grounds begin to mix with the cows and calves, ultimately forming huge postcalving aggregations. By late June or early July aggregations of 80,000 or more caribou are common. Postcalving movements and aggregations show considerable annual variation.

Although rather small in proportion to the herd's entire range, the calving/postcalving area is an important, identifiable habitat repeatedly used by the PCH during these critical life stages. The reason for repeated caribou use of this area is unclear. Varying combinations of several factors in any given year--for example, advanced emergence of new vegetation, scarcity of predators, early snowmelt, topography, and/or proximity to insect-relief habitat (Cameron, 1983)--are probably responsible for the annual variations in use.

As temperatures rise in mid- to late June, swarms of mosquitoes emerge in the 1002 area. Harassment on warm, calm days by these insects drives the caribou into dense aggregations and results in their movement to areas of relief. The groups usually move into the wind, seeking relief on points, river deltas, mudflats, auffs, large gravel bars, barrier islands, shallows of lagoons, and higher elevations in the mountains (pl. 2A). In some years there can be a gradual westward shift across the coastal plain and northern foothills.

The postcalving season is the low point of the annual physiological cycle when energy reserves of parturient cows are especially low. The stresses of winter, pregnancy, migration, birth, lactation, hair molt, antler growth, and insect harassment draw heavily upon this segment of the population (Dauphine, 1976; White and others, 1975). Access to insect-relief habitat and forage during this period may be critical to herd productivity. In early July the herd usually moves east and south, vacating the 1002 area by mid-July. In some years, residual groups numbering as many as 15,000 animals have remained on the 1002 area and adjacent foothills and mountains through August. Occasionally, remnants of such groups (up to 2,000 animals) have wintered in northern mountains and foothills.

A draft international agreement for management of the PCH has been negotiated between the Governments of the United States and Canada. The State of Alaska and Canadian Territorial governments, as well as local users, participated in the negotiations. Other interested parties also attended the meetings. The purpose of the draft agreement is to facilitate U.S./Canadian cooperation and coordination of programs and activities aimed at long-term conservation of the PCH. The agreement will ensure that the PCH, its habitat, and interests of users of the PCH are given effective consideration in evaluating proposed activities within the range of the herd. All activities having a potential impact on the conservation of the PCH or its habitat will be subject to impact assessment and review and may require mitigation under the agreement. The agreement would establish an eight-member International Porcupine Caribou Board, made up of four members from each country, to make recommendations and provide advice on those aspects of conservation of the PCH that require international coordination. The Board would serve as a means of exchanging information on and facilitating cooperative planning for the PCH throughout its range. The draft agreement, initialed by the principal negotiators in Seattle, Washington, December 3, 1986, is being reviewed and discussed through public informational meetings in both countries before signing.

The PCH is harvested in both the United States and Canada. The harvest by individual Native villages is highly variable, depending upon herd movements. Recent annual harvests from the PCH by Kaktovik, the only village adjacent to the 1002 area, have ranged from 25 to 75 animals (Pedersen and Coffing, 1984). Annual harvest of the PCH throughout its range was estimated at 3,000-5,000 animals (LeBlond, 1979). The harvest varies greatly from village to village and from year to year within the same village. The annual harvest at Arctic Village, Alaska, ranges from 200 to 1,000 (LeBlond, 1979). During 1963-86 annual harvest of the PCH within Canada averaged approximately 1,800 animals for the years in which data were available (Yukon Territory Wildlife Branch, Canadian Wildlife Service, unpublished data).

The Central Arctic caribou herd (CAH) has been increasing, and in 1985 numbered about 15,000 animals (Ken Whitten, ADF&G, unpublished data). Since the CAH was recognized as a separate herd in the mid-1970's (Roseneau and Stern, 1974b), its range has been entirely north of the Continental Divide, from the Itkillik and Colville Rivers on the west to the Sadlerochit River on the east (pl. 2B). The TAPS (Trans-Alaska Pipeline System), Dalton Highway, and Prudhoe Bay-Kuparuk oil fields lie within the herd's range (fig. I-1). In July 1983 the herd comprised 46 percent cows, 21 percent calves, and 33 percent bulls (Hinman, 1985).

Females of the CAH wintering in the mountains and foothills near the western part of the 1002 area migrate north-northwest across the rolling uplands south of Camden Bay to the calving grounds on or near the Canning and Staines River deltas. They also move northward along the Canning River.

CAH calving activity has been concentrated in two areas: (1) west of Prudhoe Bay in the vicinity of Kuparuk and Ugnuravik Rivers (including recent oil development in the Milne Point and Kuparuk areas); and (2) east of Prudhoe Bay, mainly in the Bullen Point to Canning River delta area. Most years as many as 1,000 females calve in the Bullen Point to Canning River delta (pl. 2B). Scattered, low-density calving extends as far east as the Sadlerochit River. Little or no calving has been observed in the TAPS-Prudhoe Bay oil-field area since about 1973 (U.S. Fish and Wildlife Service, 1982; Whitten and Cameron, 1985); however, concentrated calving has never been documented in the area.

After calving, some CAH caribou move southeastward to the uplands south of Camden Bay. During the insect season (July) there is often a strong eastward movement along coastal habitats between the Canning River delta and Camden Bay, the area used by as many as 7,000-8,000 caribou of the CAH for postcalving and for insect relief, given 1985 population levels (pl. 2B). During late summer, about 1,000 animals may remain scattered west of the Sadlerochit River and north of the Sadlerochit Mountains, primarily within the 1002 area. Riparian areas are used for travel as well as spring and summer feeding areas (Roby, 1978). In late summer and fall, CAH caribou are scattered across the coastal plain south of Camden Bay, in foothills north of the Sadlerochit Mountains, and in uplands south of the Sadlerochit Mountains where they remain for the winter. During most winters, scattered groups of CAH caribou range throughout the 1002 area west of the Sadlerochit River and adjacent uplands to the south. The number of wintering animals ranges from a few hundred to a thousand.

The annual harvest of CAH caribou by Kaktovik residents has most recently been estimated to be 25-75 animals (Pedersen and Coffing, 1984). This harvest occurs along the coast during the summer when residents can travel by boat and inland during the fall and spring when snowmachine travel is possible (pl. 2D).

MUSKOXEN

Muskoxen were exterminated from the North Slope by the late 1800's, so carrying capacity and past historic levels are unknown. In an effort to reestablish an indigenous population, 64 muskoxen were reintroduced to the Arctic Refuge in 1969 and 1970 (Roseneau and Stern, 1974a). The muskox population has grown exponentially since 1974 (fig. II-6) because of high productivity and low mortality. In 1985, the postcalving refuge population was estimated at 476, more than triple that in 1979.

Muskoxen are highly social and are usually found in mixed-sex herds. Herd size varies seasonally, the smallest herds occurring during the rut in August. Many bull muskoxen do not remain with a mixed-sex herd for long periods of time, but move from herd to herd, associate with other bulls in small groups, or travel alone (Reynolds and others, 1985). In response to predators or other threats, muskoxen form a compact defensive formation.

Muskoxen have used the same areas along the Niguanak-Okerokovik-Angun, Sadlerochit, and Tamayariak-Katakturuk Rivers for the past several years, with approximately 80, 160, and 230 animals, respectively, using those drainages. Muskoxen using the Sadlerochit and Tamayariak areas seem to be part of the same subpopulation, whereas animals in the Okerokovik area seem to be a separate subpopulation. Many of the cows marked for the baseline study research in 1982-85 have remained in these areas (pl. 2C) and show a high site-specific fidelity. Riparian areas are important travel corridors and muskoxen regularly feed there year-round. Mixed-sex herds are also dispersing into new areas on the Katakturuk River and drainages east of the Aichilik River.

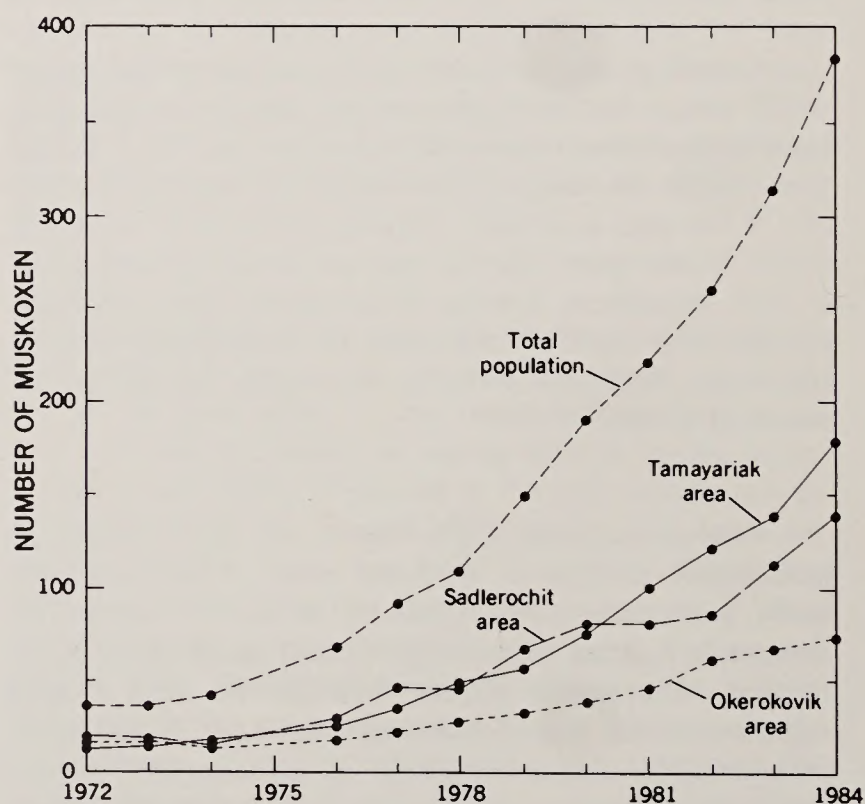


Figure II-6.--Estimated numbers of muskoxen in post-calving populations in the Arctic Refuge, 1972-84.

Table II-3.—Observed muskox range within the Arctic National Wildlife Refuge and within the 1002 area, 1982-85.

	Within Arctic Refuge (acres)	Within 1002 area (acres)	Percent of total use area within 1002 area
High seasonal or year-round use with calving.....	251,000	207,000	82
High seasonal or year-round use without calving.....	211,000	158,000	75
Total observed range, including high-use areas.....	1,116,000	760,000	68

Though not migratory, muskoxen apparently move in response to seasonal changes in snow cover and vegetation. In summer and fall, they are often found in riparian habitats along major drainages, where they feed on willows and forbs. In winter and spring many animals move to adjacent uplands having less snow cover in order to feed on tussock sedges (Reynolds and others, 1985). Preliminary FWS data indicate that muskoxen apparently reduce both their movements and activity during winter, probably as an adaptation to conserve energy. Table II-3 and plate 2C show the extent of muskoxen habitat within the Arctic Refuge and 1002 area and delineate those seasonal or year-round use areas where muskoxen have been observed most frequently, year after year.

Hunting of muskoxen on the Arctic Refuge under permit from the Alaska Department of Fish and Game started in 1983. Five bull-only permits have been issued annually; the 1983, 1984, 1985, and 1986 harvests were 4, 5, 4, and 3, respectively.



MOOSE

~ Patterns of moose distribution north of the Brooks Range vary seasonally (pl. 1C). Winter concentrations occur south of the 1002 area where as many as 203 and 239 moose have been counted in the Canning and Kongakut River drainages, respectively (Garner and Reynolds, 1986). A few moose are scattered in other river drainages (U.S. Fish and Wildlife Service, 1982; Martin and Garner, 1984, 1985). ~

In late May or early June small widely dispersed groups of moose move northward along riparian systems. Moose using the 1002 area have dispersed from populations to the south and use a variety of habitats in July and early August. The number of moose at any one time probably does not exceed 25. In late August, moose begin to aggregate; the largest groups are found south of the 1002 area in October during the rut. Most moose using the 1002 area move southward to winter in valleys of the Brooks Range. Riparian willow species comprise a major part of the forage used by moose; mountain alder, where available, is an important winter food.

Subsistence hunters from Kaktovik take one or two moose annually (Jacobson and Wentworth, 1982). Other hunters harvest a few moose, generally less than 10 annually, from the North Slope of the Arctic Refuge. Most of this harvest is in the Canning River and Kongakut drainages, and nearly all is outside the 1002 area.

DALL SHEEP

Although the estimated total population of Dall sheep within the original 8.9-million-acre Arctic Refuge is approximately 6,800, Dall sheep are rare on the 1002 area, because suitable habitat is lacking. The Sadlerochit Mountains contain an estimated 270 sheep, and constitute the northernmost extent of their range in North America (T. G. Smith, 1979).

Traditional summer range consists mainly of alpine slopes and meadows. Winter range, limited mostly by topography, consists of usually south-facing windblown slopes and ridges. FWS surveys indicate that Dall sheep have used the lower foothill terrain near Sadlerochit Spring, mostly in winter; in summer, they cross this tundra area in moving to other habitats (D. Ross and M. A. Spindler, unpublished data, 1981).



WOLVES

Wolves are found throughout Alaska's North Slope. The population density is lower on the 1002 area than in areas farther south. Wolves occupy large home ranges. In winter wolves tend to congregate in areas of overwintering caribou and possibly moose or Dall sheep. Daily movement depends on availability of prey. Estimates of density for restricted geographic areas vary widely, but most fall within the range of 6 to 200 square miles per wolf (Mech, 1970). Wolves mate in March, and pups (usually 4-7 per litter) are born in dens 2 months later. Although the 1002 area appears to contain suitable denning habitat, no dens have been found. Dens have been found in mountainous terrain 10 to 40 miles south of the 1002 area. The number of wolves using the 1002 area on a seasonal basis is low and apparently does not exceed 5-10 animals annually.

~ Populations in or adjacent to the 1002 area were depressed in the late 1970's by an outbreak of rabies. A similar outbreak occurred in 1985 when nine dead wolves, including six radio-collared animals, were found. Five of the animals were confirmed as rabid. Historical den sites on the Kongakut, Hulahula, and Aichilik Rivers were deserted in 1985, and the death from rabies of breeding wolves was suspected as the reason. However, four new dens were found, three occupied by wolves which were remnants of earlier packs. ~

Wolves on the North Slope prey on caribou, moose, sheep, ground squirrels, small rodents, and birds. Wolves are typically associated with drainage systems which they use as travel corridors. They are also attracted to riparian areas because of the abundance of prey, including ground squirrels. During the summer when prey is most abundant, wolves are distributed throughout all 1002 area habitat types (U.S. Fish and Wildlife Service, 1982; Haugen, 1984, 1985; Weiler and others, 1985). Wolves are hunted and trapped by Kaktovik residents, who harvest most in the Hulahula, Sadlerochit, and Okpilak River areas (Jacobson and Wentworth, 1982; Weiler and others, 1987). Generally, fewer than 10 wolves are harvested annually, usually south of the 1002 area.

ARCTIC FOXES

Arctic foxes move seasonally between summer breeding habitats in tundra and winter habitats along the northern Alaska coast and onto the sea ice (Chesemore, 1967). Their range is limited by habitat and interspecific competition with red foxes. Periodic outbreaks of rabies can reduce fox populations. Productivity of foxes is related to abundance of microtines (small rodents). Foxes regulate their food supply, despite fluctuating prey availability, by caching food in early summer when prey is abundant and utilizing these food caches and carrion in late summer when fewer prey are available. At Demarcation Bay arctic foxes spent most of their time in medium-relief, low-center polygon and meadow habitats, preying on small mammals and bird nests (Burgess, 1984). In 1979 when rodents were at low population levels, foxes at Demarcation Bay depended mainly on birds and eggs. No pups were produced that year (Burgess, 1984).

* Arctic foxes are trapped in the winter by Kaktovik residents for fur. The number taken annually fluctuates according to their abundance. In years of abundance more than 100 foxes may be taken. Most trapping is within 15 miles of the coast, mainly on or near Barter Island (Jacobson and Wentworth, 1982).

WOLVERINES

Wolverines frequent all types of terrain found in Arctic areas, as evident from observations and tracks. Rivers and mountains are frequently associated with territorial boundaries. Snowdrifts are important for wolverine den sites, and, in the tundra, remnant snowdrifts in small drainages are used by females for rearing their offspring (Magoun, 1985).

A few wolverines inhabit the 1002 area. Accurate population figures are unavailable, but a rough estimate of the 1002 area population can be made from the wolverine densities and assumptions used by Magoun (1985) for estimating the population in the Western Arctic. Using Magoun's assumptions, the estimated density for the 1002 area is 90 wolverines. This figure may not be accurate: Magoun's area and the 1002 area are not identical; Magoun studied a virtually unexploited population whereas wolverines in the 1002 area and environs are routinely harvested by Kaktovik residents. Furthermore, sighting records for the 1002 area are sparse; recent FWS studies have resulted in very few sightings.

Wolverines feed opportunistically and have been reported pursuing large ungulates such as caribou, moose, and Dall sheep, though they are more commonly scavengers than predators. In the Arctic, ground squirrels are an important food (Rausch and Pearson, 1972). Caribou are scavenged, particularly during May and June when they are numerous. During June and July, wolverines prey on birds and eggs.

Kaktovik residents hunt wolverines most frequently in the foothills and northern mountainous areas of the Sadlerochit, Hulahula, and Okpilak Rivers. ADF&G records indicate that an average of about one wolverine per year is harvested; this may be an underestimate because of incomplete reporting. Magoun (1985) believed that harvest in Game Management Unit 26A (Western Arctic) was 2 to 10 times greater than reported. During the winter of 1980-81, seven wolverines were taken by Kaktovik residents (Jacobson and Wentworth, 1982). Wolverine are sometimes harvested by trappers near the village of Kaktovik. These animals are mostly subadults that may be dispersing onto the 1002 area from the foothills to the south. It is not known whether the 1002 area wolverine population is resident or transient.

BROWN BEARS

Brown bears seasonally use the 1002 area. Brown bears north of the Brooks Range are at the northern limit of their range. At periods of greatest abundance (in June) use is estimated at one bear per 30 square miles, or approximately 108 bears (Garner and others, 1984). These populations are characterized as having low reproductive rates as a result of short periods of food availability, large individual home ranges (95 to 520 square miles), and habitats that provide little protective cover (Reynolds and others, 1976; Reynolds, 1979; Garner, Weiler, and Martin, 1983).

Brown bears are found throughout the entire 1002 area. They appear in late May and are generally most abundant during June and July when caribou are most plentiful. The bears breed during this same period. There are two known high-use areas. One, used by 50-70 adult bears and cubs, is in the southeastern part of the 1002 area where caribou calving is concentrated. The second, used by 15-20 bears, is a much smaller area along the upper reaches of the Katakaturuk River (pl. 1D). Moderate-use areas (30-80 bears) are located between and around the high-use areas and are generally used for a shorter period (June-July). (Note that bear numbers from each use area cannot be added because they represent different times of residency. Each bear may use more than one or all areas delineated.) After caribou leave the 1002 area in early July, brown bears gradually move south into the foothills and mountains (Garner and others, 1983, 1984, 1985). Riparian areas are used as travel corridors. Brown bear habitat changes seasonally according to food availability (U.S. Fish and Wildlife Service, 1982). Spring foods include vegetation, carrion, caribou, ground squirrels, and rodents. River courses frequently contain abundant prey as well as preferred vegetation. During mid- to late summer, brown bears shift to eating horsetail, grasses, and sedges. In the fall, they eat wild sweetpea roots, crowberries, blueberries, bearberries, and ground squirrels and other rodents (Phillips, 1984).

Denning occurs in late September and October, depending on soil conditions (the top soil must be frozen to support den excavation) and weather (Pearson, 1976; Reynolds and others, 1976; Garner and others, 1983, 1984, 1985). Most dens are in the foothills and mountains south of the 1002 area; only seven of 199 (3.5 percent) known den sites within the northeast portion of the Arctic Refuge have been found on the 1002 area (Garner and others, 1983, 1984, 1985; Garner and Reynolds, 1986). Cubs are born in January and early February. Litters range from one to three; the average litter for bears using the 1002 area is 1.9 (Garner and others, 1984). Brown bears emerge from winter dens in late April through May. On the 1002 area the survival rate among cubs and yearlings ranges from zero to 100 percent. Causes of juvenile mortality are not well known, but a major cause is probably the killing of juveniles by mature males such as occurs in other brown bear populations (Stringham, 1983).

Kaktovik residents harvest an average of 2 brown bears annually. The bears are taken opportunistically on the 1002 area or farther south in the foothills or mountains (Jacobson and Wentworth, 1982). The sport harvest within the Arctic Refuge north of the Brooks Range averages 2-4 brown bears annually. Virtually all sport harvest is south of the 1002 area.

ARCTIC GROUND SQUIRRELS AND OTHER RODENTS

Arctic ground squirrels are found throughout the 1002 area in colonies restricted to well-drained soils free of permafrost. Ground squirrels hibernate from late September through May (Garner and Reynolds, 1986). Activity resumes in the spring, before the snow begins to disappear. Mating is followed by a 25-day gestation period. Young ground squirrels grow rapidly in preparation for winter hibernation.

Ground squirrels are a subsistence food for Kaktovik residents. They are also important in the diets of snowy owls, rough-legged hawks, brown bears, golden eagles, arctic foxes, red foxes, and wolves.

Other rodents found on the 1002 area include the collared lemming, brown lemming, and tundra vole. Red-backed voles and tundra voles may occur in the foothills in the southern part of the 1002 area. The brown lemming is the leading herbivore along the coast, and in high population years can account for more plant consumption than ungulates (Batzli and others, 1980). Their impact on the vegetation is cyclic and corresponds to the 3- to 5-year population cycle. Lemmings and voles are active all year, grazing frozen plant material and breeding under the snow. Maximum population densities occur after successful winter reproduction. Shallow snow depths result in low temperatures under the snow, creating an energy stress that can reduce winter reproductive success.

MARINE MAMMALS

Fourteen species of marine mammals may occur off the coast of the Arctic Refuge. Some of these--the spotted seal and walrus--are occasional visitors. Others such as the killer whale, gray whale, humpback whale, fin whale, narwhal, harbor porpoise, and hooded seal are rarely seen because this part of the Beaufort Sea is at the extreme margin of their ranges. Five of the species were evaluated: polar bear, ringed seal, bearded seal, beluga whale, and the endangered bowhead whale.

~ All marine mammals in U.S. waters are protected under the Marine Mammal Protection Act of 1972 (16 U.S.C. 1361). The goal of that Act is to restore and maintain marine mammal populations at their optimum sustainable population levels, as well as to protect subsistence opportunities for Alaska Natives. The Act establishes a moratorium on the taking (including harassment) and importation of marine mammals except by Alaska Natives for nonwasteful subsistence or handicraft purposes. Required negotiations to encourage international arrangements for research and conservation of all marine mammals have resulted in the 1976 international agreement on polar bears as discussed in that section. ~

POLAR BEARS

~ Polar bears are closely associated with pack ice of the Arctic Ocean throughout most of the year. The Beaufort Sea population of polar bears is estimated to be 1,300-2,500 (Amstrup and others, 1986). Some females move to coastal areas, and occasionally farther inland, during October and November to seek maternity den sites. Pregnant polar bears, and later their cubs, probably spend more time on the 1002 area than other segments of the polar bear population. Other groups of polar bears seasonally frequent the coastal periphery of the area. Recapture of polar bears marked by the FWS in recent years indicates that an influx of females accompanied by cubs as old as 20 months and subadult animals coincides with the fall ice-edge advance to the shoreline. ~

~ Polar bear dens have been found as far as 250 miles offshore and 32 miles inland. Eighty-five percent of dens located in 1983-86 were offshore. The onshore area from the Colville delta to the Canadian border is used by the Beaufort Sea population for denning. However, the most consistently used land denning areas were on and adjacent to the 1002 area where 1-2 dens were found by radio telemetry in 5 of the 6 years between winter 1981-82, when the FWS began a continuing study of North Slope polar bears, and winter 1986-87 (Amstrup, 1986; FWS, unpublished data). The ideal denning sites are riverbanks, draws, and the leeward side of bluffs and hills where snow accumulation is sufficient to support den construction. Sixteen dens were found in the 1002 area between 1951 and 1986 through FWS radio telemetry studies and Native reports (pl. 1E; Garner and Reynolds, 1986, table 15, p. 293; FWS, unpublished data). Another five dens have been located on ice near the 1002 area. ~

~ Three different parts of the 1002 area (pl. 1E) have been generally delineated as confirmed denning areas, that is, areas in which polar bear dens and denning activity have been observed during more than one winter. Dens or denning activities have also been observed in other 1002 area locations, but data are inadequate to confirm recurrent use. Ten of the 12 land dens found through radio telemetry studies (1981-86) have been located on the Arctic Refuge; the other two were on Hershel Island, Canada. ~

Female polar bears that den on land move onshore to seek out den sites in October and November, depending on ice movement and ice buildup (Lentfer and Hensel, 1980). Denning females give birth to 1 or 2 cubs in December or January, and bears emerge in late March or early April, depending upon weather conditions. The female and cubs generally remain near the den, making short forays for 1 to 2 weeks until the cubs gain strength and become acclimated to outside conditions. Soon thereafter, they move to the sea ice to feed on seals. Many females with new cubs concentrate their foraging on the shore-fast ice, which can extend out to 30 miles.



When the nearshore ice breaks up in the spring, the bears move with the sea ice and many concentrate at the south edge of the pack ice. This position varies seasonally but usually is between the coast and latitude 72°N.

Except for a shore lead, the Beaufort Sea is ice covered year-round. Nearshore open water begins to freeze in September or October, and nearshore ice does not melt until May or early June. Male and nondenning female polar bears inhabit the sea ice throughout the winter. The distribution of polar bears is influenced by the availability of their major prey species, ringed and bearded seals, which concentrate in areas of drifting pack ice (Lentfer, 1971; Stirling and others, 1975). Ringed seals probably constitute 95 percent of the polar bear's diet (Burns and Eley, 1978).

Polar bears are protected under the provisions of the Marine Mammal Protection Act of 1972. Additionally, an international agreement for the conservation of polar bears was ratified in 1976 by the governments of Canada, Denmark, Norway, the Union of Soviet Socialist Republics, and the United States of America. The treaty requires management of shared populations by consultation. Article II requires that appropriate actions be taken to protect ecosystems of which polar bears are a part, especially denning and feeding sites.

~ Large numbers of polar bears have concentrated seasonally in some years along the coast of the Arctic Refuge near the village of Kaktovik where whale carcasses can be scavenged (Amstrup and others, 1986). Each year many bears are available to local subsistence hunters, but in most recent years the kill has been small (FWS, unpublished data). Annual subsistence harvest of polar bears by local residents was as high as 23 to 28 in 1980-81; at least one polar bear was confirmed as being taken in each of the following 6 years, with two bears being taken in 1984-85 and three in 1985-86 (table II-7) (Schliebe, 1985; Jacobson and Wentworth, 1982; FWS, unpublished data). Restricting the take of females and family groups to ensure population stability was a purpose of the November 1986 agreement between the North Slope Borough Fish and Game Management Committee and the Inuvialuit Game Council in Canada. ~

SEALS AND WHALES

Ringed seals, bearded seals and, occasionally, spotted seals are found in the Beaufort Sea and along the coast north of the coastal plain, including the lagoons of the 1002 area (Garner and Reynolds, 1986; U.S. Fish and Wildlife Service, 1982). Although there is some evidence of ringed seals within the refuge in summer and fall, their primary habitats are generally outside the 1002 area. Ringed seals use stable, shore-fast ice as their primary pupping habitat (T. G. Smith, 1980). To improve chances of successfully rearing pups, older, more-dominant female ringed seals select and actively defend territories on stable shore-fast ice for pupping. Subadult and younger females are forced to construct lairs on active pack ice, increasing the chances of predation by polar bears. Bearded seals are chiefly associated with the pack-ice edge throughout the year. Primary breeding and pupping habitat is associated with the ice edge. A small number of bearded seals remain in northern ice-bound areas. The extent of active pack ice use by seals within the 1002 area is not well understood. However, seals in Canada do occupy active pack ice, a preferred hunting area for polar bears (T. G. Smith, 1980).

Kaktovik residents harvest spotted, ringed, and bearded seals for subsistence, though relatively few are taken (Jacobson and Wentworth, 1982).

Bowhead and gray whales are listed as endangered species. Gray whales are occasionally found in the Beaufort Sea north of the 1002 area (U.S. Fish and Wildlife Service, 1982). The bowhead whale inhabits waters offshore from the Arctic Refuge in September and October during its fall migration along the Beaufort Sea coast. The southern boundary of the bowheads' fall migration corridor is generally the 66-foot isobath, although they are occasionally seen in shallower water. These whales feed in Demarcation Bay east of the 1002 area; they also may use waters off the 1002 area (National Marine Fisheries Service, 1983). Belukha (beluga) whales also migrate through waters north of the 1002 area.

Bowhead whales are taken for subsistence by Kaktovik residents. During 1981-85 the annual harvest has averaged one whale, with an average of one additional whale struck and lost each year.

BIRDS

~ One hundred thirty-five species of birds have been recorded on the Arctic Refuge coastal plain (Garner and Reynolds, 1986, 1987). The majority are migratory, present only from May to September. Six species are considered permanent residents--rock and willow ptarmigan, snowy owl, common raven, gyrfalcon, and American dipper. The common and hoary redpoll, ivory gull, and Ross' gull are occasionally seen in winter on the 1002 area. Twenty-one species are found offshore, mostly from late July to mid-September, with distribution generally limited to within 35 miles of shore. Sixteen offshore species breed locally on coastal tundra or barrier islands (Bartels, 1973; Divoky, 1978). Greatest concentrations of summer resident waterbirds on the Arctic Refuge occur in two general habitats: shallow coastal waters and tundra wetlands (pl. 3, A and B). ~

~ Birds begin using coastal lagoons when the snow melts in late May and river overflows cover lagoon deltas, providing the first open water of the season. Habitat use during the breeding season (mainly June and July) varies with bird species. Peak numbers of birds are often seen in August and September during staging and early migration. Smaller numbers are present until freezeup in late September or early October, when most birds leave the area. ~

~ Lagoon areas are important during all phases of the avian life cycle. More than 35,000 waterbirds of up to 33 species (primarily oldsquaw) may use the coastal lagoons during the open-water period (July-September) (Garner and Reynolds, 1986). As many as 11,000 birds may be present in a lagoon at one time. Some birds move from terrestrial nesting habitats into shallow lagoons, bays, and sand spits to molt, finding protection from predation during this flightless stage. The lagoons are also important feeding areas for oldsquaw, eiders, scoters, and other ducks, loons, phalaropes, terns, gulls, jaegers, and black guillemots (Divoky, 1978). ~

Migratory birds range internationally; nesting and wintering grounds and migration routes may occur not only in different countries but on different continents. International treaties for the protection of migratory birds have been ratified between the United States and the Union of Soviet Socialist Republics, Japan, Canada, and Mexico. In addition, measures for the protection of migratory birds are contained in the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, an agreement to which the United States is a party.

Species-specific information follows, under five categories: swans, geese, and ducks; seabirds and shorebirds; raptors; ptarmigan; and passerines.

SWANS, GEESE, AND DUCKS

~ Tundra swans are common breeding birds of the thaw-lake plains. As many as 100 nests and 280 to 485 adult swans have been counted on the 1002 area during annual surveys (Garner and Reynolds, 1986). Swans arrive in late May and early June and concentrate on the Canning-Tamayariak delta, the Hulahula-Okpilak delta, Barter Island lakes, Jago River wetlands, the Aichilik-Egaksrak deltas, and lakes in the Demarcation Bay area (pl. 3A). Spring surveys in 1982-85 showed an average density of 1 swan per 0.67 square mile in concentration areas. These areas apparently offer highly desirable swan nesting and feeding habitat. Average density for the overall 2,960-square-mile area studied was 1 swan per 7.7 square miles. Swans depart the breeding grounds from late August to late September, those swans with young being last to leave (U.S. Fish and Wildlife Service, 1982; Bartels and Doyle, 1984a, b; Bartels and others, 1984; Brackney and others, 1985a, b). ~

Four species of geese regularly use the 1002 area: Canada geese, black brant, greater white-fronted geese, and lesser snow geese. Canada geese and black brant may breed there each year; however, the size of the breeding population is unknown, and the coastal plain is not a major nesting area. Geese nest on islands and peninsulas associated with the drained-basin wetlands of the thaw-lake plains and river flood plains. Canada geese with broods seek lakes and lagoons for protection shortly after their goslings hatch. Brant breeding areas are usually found near the mouths of large rivers. In late June, nonbreeding and failed breeding pairs begin to molt. Some of these individuals may move west prior to molting (pl. 3B). Several hundred molting Canada geese and brant have been observed in late July and early August along the Arctic Refuge coastline.

~ Staging lesser snow geese congregate on the Arctic Refuge coastal plain in mid-August and may remain through late September (pl. 3B). These geese nest chiefly on Banks Island (200,000 breeding birds), Anderson River delta (10,000 breeding birds), and Kendall Island (1,000 breeding birds) (Krebs, 1983) in Canada and, prior to fall migration, most move westward into the 1002 area only as far as the Hulahula River. Several hundred snow geese may use the Canning River delta and Katakaturuk Plateau during fall staging. More than 595,000 birds were estimated for the entire staging area on the coastal plain in Alaska and the Yukon Territory, Canada in 1985 (FWS, unpublished data). The maximum estimated for the Arctic Refuge coastal plain (the 1002 area plus adjacent Wilderness coastal plain) was 325,760 in 1978 (Spindler, 1978), with an 11-year average of 136,000. The average number of geese using the 1002 area is 105,000, an approximate average of 22 percent of the Western Arctic population. Distribution of staging snow geese on the 1002 area is highly variable. Preferred staging areas shift annually among the Niguanak-Okerokovik area, the Jago-Bitty-Okerokovik area, the Jago-Bitty-Okpilak River area, and the lower Aichilik and Angun Rivers between

the 400- and 1,000-foot contours. Staging geese move as far as 225 miles west of their southward migration corridor on the Mackenzie River to take advantage of the food resources on the Yukon and the Arctic Refuge coastal plain. The geese feed heavily to accumulate fat reserves for the fall migration flight. Significant weight gains have been reported in fall staging snow geese on the North Slope (Patterson, 1974; Brackney, Masteller, and Morton, 1985a). ~

As many as 10,000 greater white-fronted geese and 10,000 black brant use the Arctic Refuge coastal plain for fall staging and migration from late August through mid-September. The white-fronted geese congregate with snow geese and move east during migration (Martin and Moitoret, 1981) to the Mackenzie River, then south through the Mackenzie River valley and into the Canadian Provinces and the western U.S. (Koski, 1977a, b; Bellrose, 1980; Barry, 1967). Coastal salt marshes and mudflats in the river deltas are especially important habitat for the westward-migrating black brant at this time (pl. 3B). During spring migration, reported arrival dates for geese range from mid-May to early June (Martin and Moitoret, 1981; Garner and Reynolds, 1987). Brant rely heavily on vegetated coastal mudflats during spring migration when the availability of suitable foraging areas is critical to ensure healthy arrival on the breeding grounds.

Several species of ducks use the 1002 area, the coastal lagoons, and nearshore Beaufort Sea waters during summer. Ducks arrive during spring migration in late May and early June (Martin and Moitoret, 1981; Garner and Reynolds, 1986). Early-arriving ducks are attracted to overflow water at river mouths until open water becomes available in nearby lakes and wetlands. Northern pintail, American wigeon, greater scaup, oldsquaw, common eider, and king eider breed on the 1002 area; the oldsquaw is the most numerous breeder. Nesting density throughout the 1002 area is generally low; locally, nesting densities in wetland complexes around river deltas and other coastal areas may be higher.

Probably more important than breeding habitat, the lakes and wetlands, coastal lagoons, and nearshore Beaufort Sea waters provide important molting and staging areas for several duck species. Oldsquaw are the vast majority of waterbirds using the 1002 area. As many as 33,000 postbreeding oldsquaw congregate in coastal lagoons, nearshore waters, and large open lakes during the midsummer molt period and remain throughout the summer. The movement of oldsquaw and common and king eider continues to late summer. Fall migration includes movement of females, juveniles, and late-molting individuals along the Beaufort seacoast. Many ducks that breed outside the 1002 area use coastal lagoons and nearshore waters as staging areas during molt and fall migration. In midsummer, scoters (especially surf scoters) and eiders (especially common eiders) move westward along shorelines and lagoons. At the same time, pintails migrate eastward over the coastal tundra.

~ Waterfowl and their eggs are taken for subsistence. The largest harvest occurs from May through early June, though birds are taken throughout the summer (Jacobson and Wentworth, 1982). From July 1985 to July 1986, Kaktovik residents harvested approximately 513 geese, mostly brant, and 251 ducks (S. Pedersen, ADF&G, unpublished data). Virtually all species of waterfowl are used, oldsquaw being the most abundant and geese the most prized. ~

SEABIRDS AND SHOREBIRDS

Seven species of seabirds are known to breed in the 1002 area: three jaegers (pomarine, parasitic, and long-tailed), two gulls (glaucous and Sabine's), arctic tern, and black guillemot. Jaegers are widely distributed over all habitat types, but their breeding population is comparatively small except in years of high microtine populations. Glaucous gulls and arctic terns are widely distributed, reaching greatest densities in tundra wetlands near the coast, but they occur in limited numbers on the 1002 area. Sabine's gulls and black guillemots are highly localized. The only known nesting areas of Sabine's gull in the 1002 area are on the Canning River delta. Black guillemots nest only on the coastal beaches and shorelines. Gulls, terns, and jaegers feed and nest along the coastline and major coastal rivers. Jaegers feed on small birds, eggs, insects, lemmings, and carrion (U.S. Fish and Wildlife Service, 1982).

~ Shorebirds are present on the coastal plain from mid-May through the end of September in all habitats (pl. 3C). Tundra habitats within river delta areas and riparian habitats are particularly important to nesting and staging shorebirds. Eighteen species of shorebirds have been recorded as breeding on the coastal plain. Most abundant are pectoral and semipalmated sandpipers, lesser golden plovers, red-necked and red phalaropes, ruddy turnstones, and long-billed dowitchers. Other common breeders are Baird's, stilt, and buff-breasted sandpipers; dunlin; black-bellied and semipalmated plovers; and wandering tattlers. Occasionally snipes and whimbrels nest on the coastal plain. Along the coast, seasonal fluctuations in shorebird numbers are characterized by highs each year in mid-June (arriving birds), early July (nonbreeding transients), and late August (departing birds). More than 2 million shorebirds are estimated to be present on the coastal plain from mid-June to mid-July (U.S. Fish and Wildlife Service, 1982). Mudflats on river deltas, particularly the Canning, Okpilak/Hulahula, and Jago, and thaw-lake ponds along the coast are important stopping points for several species of migratory shorebirds. ~

RAPTORS

~ Rough-legged hawks, golden eagles, gyrfalcons, merlins, snowy and short-eared owls, as well as the threatened arctic peregrine falcon are found on the coastal plain. (Additional details are in the subsequent section on the peregrine falcon.) Rough-legged hawks nest on river bluffs and near steep foothill slopes; golden eagles nest in

the foothills and mountains of the Brooks Range; gyrfalcons nest on the cliffs along rivers or on isolated upland cliffs; and owls nest on the open tundra (pl. 3D). These birds use the coastal plain mostly as a feeding area. Raptors generally arrive in mid-May, except for gyrfalcons which are resident and begin nesting as early as March. Raptors prey upon small rodents, ptarmigan, waterfowl, and other birds, and so their populations and distributions vary with the availability of prey. Snowy owl and short-eared owl population peaks are directly related to the microtine cycle. Concentrations of 25-75 golden eagles (mostly immature birds) are found on the PCH calving grounds and postcalving areas, where they prey on young calves and scavenge caribou carcasses (Mauer, 1985). ~

PTARMIGAN

Willow ptarmigan and rock ptarmigan are common breeders and fairly common winter residents of the 1002 area. Both species are less common near the coast than inland, but rock ptarmigan are more common than willow ptarmigan at coastal sites. Little is known of the wintering status of these species on the 1002 area, although they are present. A general northward migration of willow ptarmigan occurs in April and early May as flocks totaling several thousand birds move from the Brooks Range north toward the 1002 area. In the spring, ptarmigan are commonly observed in riparian willow or on exposed ridges and bluffs where the earliest snowmelt occurs; later they move elsewhere for nesting. Rock ptarmigan nest in nearly all habitats except the very wet sites; willow ptarmigan prefer drier upland sites with moist sedge shrub or tussock habitat. In the postbreeding season, flocks and broods of both species usually move into riparian willow habitat.

Willow and rock ptarmigan are frequently hunted for subsistence by Kaktovik residents. In midwinter, willow ptarmigan are hunted on the 1002 area. Rock ptarmigan are hunted mostly in the spring (April-May).

PASSERINES

Many passerines, or perching birds, use the 1002 area during summer (pl. 3C). Erect riparian willow stands support the highest nesting density and diversity of passerine species. The common and hoary redpolls, white-crowned sparrow, yellow wagtail, and American tree sparrow are largely restricted to riparian willow thickets or adjacent riparian Dryas terrace or gravel bars which also support willow growth. Savannah sparrows use similar habitats, but are also found in uplands, tussocks, and coastal areas. Snow buntings seem to be limited to bluffs near the coast and around buildings. Lapland longspurs are the most abundant species nesting in all tundra types. Only two passerine species are resident, the common raven and the American dipper. Some raven nesting areas are shown on plate 3D. American dippers are probably restricted in winter to the only open water available, which is near Sadlerochit and Shublik Springs.

FISH

~ Fish in the Arctic have developed extreme adaptations to a harsh environment. There is a limited period in which food is available to fish and generally a limited area in which they can survive during the long winter. ~

Coastal waters of the Beaufort Sea in Alaska contain 62 marine and anadromous species, including arctic char, arctic cisco, arctic flounder, arctic cod, boreal smelt, and fourhorn sculpin (Craig, 1984). Nearshore waters and the brackish lagoons provide migrational corridors for anadromous fish and are extremely important feeding areas for these species.

Marine nearshore waters are important spawning and overwintering areas for some marine fishes such as arctic cod, arctic flounder, and fourhorn sculpin. River deltas are also believed to be important overwintering areas. Suitability of deltas for overwintering depends largely on the salinity tolerances of species using the areas.

~ The Canning River has been studied more than any other fresh-water system in the 1002 area. Species reported include arctic char, arctic grayling, round whitefish, ninespine stickleback, and burbot. Arctic flounder, fourhorn sculpin, broad whitefish, arctic cisco, and least cisco have been reported in the lower river near the mouth. Pink, chum, and sockeye salmon have been reported in the Canning River but are thought to be strays from other systems. Lake trout are found in several lakes within the Canning River drainage but outside the 1002 area. Other streams in the 1002 area (pl. 1B) that support major fish populations are listed below. ~

River system	Arctic grayling	Arctic char	
		Resident	Anadromous
Tamayariak River.....	X	-	-
Itkilyariak Creek	X	X	-
Sadlerochit River.....	X	X	-
Hulahula River.....	X	-	X
Akutoktak River.....	X	-	-
Okpilak River	X	-	-
Aichilik River.....	X	-	X

These and many other smaller streams and coastal lakes have populations of ninespine sticklebacks. The other major streams (Katakturuk River, Marsh Creek, Carter Creek, Jago River and tributaries, Niguanak River, Sikrelurak River, Angun River, and Kogotpak River) apparently do not support major fish populations. They may support fish locally and serve as summer feeding areas for a few fish but seemingly lack adequate overwintering habitat.

The drainages that originate in or transect the 1002 area range from small intermittent-flow tundra streams to the Canning River which has an estimated 50-year flood discharge of 13,500 cfs (Childers and others, 1977). The integrity of riparian areas is important for maintenance of water quality and fish stocks on the coastal plain. Most of the water results from precipitation, surface permafrost-thaw processes, deep-lake drain, or springs. Peak flows are associated with snowmelt in early summer or with rainfall during late summer and fall. By late October, most rivers have no measurable flow. As riffle areas freeze to the bottom, overwintering fish become isolated in deeper pools, spring areas, or brackish river deltas. Substantial movement from summer feeding areas to small overwintering areas has been recorded (West and Wiswar, 1985). Ice accumulation is thickest from late March through early May.

Available fish overwintering habitat, such as deeper pools, is greatly reduced in early spring. Although pool depth is important, several other factors affect suitability for overwintering. These factors, which ultimately affect dissolved oxygen concentration, include density of organisms in the pool area, species' physiological tolerances, volume of the pool, temperature, amount of organic matter, and the influence of springs. Overwintering habitat is probably the greatest factor limiting Arctic anadromous and fresh-water fish populations (pl. 1B).

Springs supply most, if not all, of the free-flowing water during late winter. The importance of springs for spawning, rearing, and overwintering arctic fish populations has been well documented in the Arctic Refuge and other Arctic areas. Macro-invertebrates (aquatic insects consumed by fish) are generally much more abundant and diverse in springs and spring-fed sections of stream channels than in other Arctic Refuge stream habitats (Glesne and Deschermeier, 1984).

Lakes are uncommon in the 1002 area. The few that exist are generally thaw lakes located along the coast. Lakes less than 6 or 7 feet deep generally lack fish overwintering capabilities: they either freeze to the bottom by late winter or their water quality is poor due to freeze concentrations of dissolved solids and low dissolved-oxygen levels. Lakes near the coast may be brackish, owing to saltwater intrusion or windblown ocean spray. In contrast to lakes further inland, some shallow coastal lakes may be important summer feeding areas for anadromous and marine fish, depending on access.

Coastal lakes near the Canning River delta, sampled during summer, have contained arctic char, arctic grayling, arctic flounder, round whitefish, and broad whitefish (Ward and Craig, 1974). In deeper mountain and foothill lakes south of the 1002 area, arctic char, arctic grayling, and/or lake trout may be found. The lakes best known and most widely used for recreation and subsistence are Lake Peters and Lake Schrader in the headwaters of the Sadlerochit River. These contain all three of the aforementioned fish species.

Most Native subsistence use of fish occurs along the coast. Arctic char and arctic cisco are the primary species caught during summer when they are present in large numbers in the Arctic Refuge lagoons. The arctic cisco is an international resource believed to originate in the Mackenzie River in Canada. Some subsistence use of arctic cod occurs in winter in apparent response to its increased abundance during that time. Arctic cod (Lowry and others, 1978) also constitute more than 95 percent of the diet of ringed seals which, in turn, are the major prey of polar bears. Some winter subsistence fishing also occurs at fresh-water overwintering sites. The most notable of these are Fish hole 1 and Fish hole 2 on the Hulahula River (pl. 1B) where arctic char and arctic grayling are caught through holes in the river ice.

Sport fishing is currently minimal because of difficulty in access and seasonal limitations on fish abundance.

THREATENED AND ENDANGERED SPECIES

~ The Endangered Species Act of 1973 (16 U.S.C. 1531) provides for the conservation of endangered and threatened species. Taking, importing, transporting, or selling endangered and threatened species is prohibited under the Act, except for nonwasteful subsistence purposes by Alaskan Natives or non-Natives who are permanent residents of Alaskan villages. Federal agencies are prohibited from any action that would jeopardize the continued existence of listed species. ~

BOWHEAD AND GRAY WHALES

Bowhead and gray whales are listed as endangered under the Endangered Species Act of 1973, as amended. Both species migrate into or through the Beaufort Sea, north of the 1002 area, although sightings of gray whales are rare. In-migrations of bowheads occur after spring breakup, and out-migrations take place before fall freezeup.

ARCTIC PEREGRINE FALCON

Listed as a threatened species under the Endangered Species Act of 1973, the arctic peregrine falcon is the only terrestrial threatened or endangered species found in the 1002 area. In Alaska, most peregrine falcons nest on ledges of cliffs or bluffs along river courses, but cliff habitat is not abundant in the Arctic Refuge north of the Brooks Range. But a few peregrines have been reported nesting there in past years (Cade, 1960; Roseneau and others, 1976; Amaral, 1985; Amaral and Benfield, 1985). Historically, peregrines occupied eyries along the Canning, Katakturuk, Sadlerochit, Hulahula, Jago, Aichilik, and Kongakut Rivers (U.S. Fish and Wildlife Service, 1982). Among the eyries formerly or potentially occupied by peregrines within the Arctic Refuge, only two are within the 1002 area. These sites are on bluffs along the Sadlerochit River near the spring and at Bitty Benchmark on the Jago River (pl. 3D).

Peregrine falcons are highly migratory and spend a relatively short time in Alaska. Arctic peregrines generally arrive at their North Slope eyries between April 21 and May 7, lay and incubate eggs between May 15 and July 21, and young fledge (leave the nest) during August (U.S. Fish and Wildlife Service, 1982). Generally, the breeding season is defined as the period from April 15 to August 31.

There appears to be a significant movement of arctic peregrine falcons through the 1002 area from late August to mid-September (Martin and Moiteret, 1981; U.S. Fish and Wildlife Service, 1982). The number and timing of these observations suggest that at least some North Slope arctic peregrines migrate along the coast of the Beaufort Sea. The lagoons, river mouths, and bays concentrate shorebirds and waterfowl, which are favored prey of the peregrine.

Nesting of peregrines in the Arctic Refuge north of the Continental Divide was documented in 1972-73 when three sites near the confluence of the Marsh Fork and Canning River 40 miles south of the 1002 boundary were occupied (Roseneau, 1974), and in 1984 and 1985, when pairs nested along the Canning and Aichilik Rivers outside the 1002 area. Several sightings during June and July have been reported from the 1002 area (U.S. Fish and Wildlife Service, 1982; Amaral, 1985; Amaral and Benfield, 1985; Oates and others, 1986). The significance of these observations is unclear, as the birds did not appear to be associated with nest sites, yet the observations do indicate that, in addition to those present during migration, a few scattered peregrines (possibly nonbreeders) can be found in the 1002 area during the breeding season.

HUMAN ENVIRONMENT

Population

The North Slope Census Region comprises the entire 88,281-square-mile northern coast of Alaska. The region is sparsely populated, having a density of one person per 220 square miles. With the exception of Anaktuvak Pass, the human population lives on or near the coast. The majority of residents are Inupiat Eskimo, but about 6,200 nonresidents are employed in isolated, self-sufficient large to medium-sized industrial or military enclaves (NSB, 1984a).

Population figures for the Census Region are derived for several purposes and must be checked to see which data are used. For example, the U.S. Census 1980 population was 4,199 but did not include workers at Prudhoe Bay as "residents"; the 1980 population including both residents and the nonresident workforce was 9,234 (NSB, 1984b). In comparison, the 1970 population of Prudhoe Bay was 217.

The NSB Comprehensive Plan uses an annual population growth rate of 2 percent and assumes a doubling of the Eskimo population for the region in 35 years (3,034 in 1980 to 6,000 by 2015).

Kaktovik is the only settlement near the 1002 area. The 1980 U.S. Census listed Kaktovik's population as 165, a 34-percent increase over the 1970 population. The 1983 population shows another increase, although counts differed: 185, according to an April 1983 population count by Pedersen, Coffing, and Thompson (1985), and 203 according to the North Slope Borough (NSB, 1984b). Nearly 90 percent of the population is of Native Inupiat Eskimo descent. The population increase since 1970 has primarily resulted from the return of residents formerly living in Barrow to the village because of improved housing and employment opportunities. Key features of the community are family and cultural ties, ties to the land, and economic opportunity for both jobs and subsistence. Community growth will probably continue if current trends for services and other village improvements continue (U.S. Bureau of Land Management, 1978).

~ Sociocultural System ~

In both the Inupiat and the Athabascan cultures of the Arctic, subsistence production is closely and intricately tied to a larger cultural framework of values. The harvest of renewable resources for local consumption is the cultural as well as economic foundation of human life for many of the people in this region. Embodied in the subsistence way of life is harvesting of the resources to meet nutritional needs, development of a self-image, transfer of cultural values to offspring during harvesting activities, and weaving of the social fabric through resources distribution to the extended family and beyond.

Western culture with its cash-based economy has already had a significant effect on the traditional Native culture, and the rate of change has accelerated in recent decades. There are benefits in the form of increased material well-being, education and health services. Nonetheless, alcoholism, drug abuse, and mental illness have increased dramatically during this period of intense cultural change.

The present subsistence way of life continues to support the material and emotional well-being of the villages. But severe strains are being placed on the adaptability of the culture by such recent major events as ANSCA, ANILCA, and economic developments. Subsistence activities have served as an anchor for Native cultures in these times of change and will continue to do so as long as adequate resources are available. The ability of the villagers to maintain their present way of life in combination with a mixed cash/subsistence economy will depend on several factors, among them the manner in which resources are developed; regional, local and individual efforts to manage sociocultural impacts; and the health of subsistence resources.

The Native culture in the area is not weaning itself from a subsistence way of life and purposefully converting to a cash economy; rather, it is using each for the support of the other to provide a balance.

Existing Land Use

SUBSISTENCE USE

~ Responsibilities for subsistence management and use on Federal lands are derived from Title VIII of ANILCA. Under section 803, "subsistence uses" are defined as "the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of nonedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade." Under the Marine Mammal Protection Act of 1972, and the Endangered Species Act of 1973, Alaska Natives are also permitted, under certain circumstances, to harvest marine mammals and endangered or threatened species when such harvest is for subsistence purposes. ~

~ Fish and wildlife populations in or adjacent to the 1002 area are utilized for subsistence by communities in northern Alaska and in the northern Yukon. Because it is located adjacent to the 1002 area, the community of Kaktovik is of primary concern relative to subsistence uses within the 1002 area. ~

KAKTOVIK

The ADF&G Division of Subsistence recently completed a detailed investigation, begun in 1980, of Kaktovik subsistence use (Pedersen and others, 1985). That study elaborated upon the previous work by Jacobson and Wentworth (1982) and Wentworth (1978). The 1981-82, 1982-83, and 1983-84 caribou harvest by Kaktovik residents was also reported by ADF&G (Pedersen and Coffing, 1984). Figure II-7 displays Kaktovik's subsistence species use by season.

Approximately 68 percent of Kaktovik's present subsistence use area is within the Arctic Refuge (Pedersen and others, 1985). This area extends as far south as the headwaters of the Hulahula River and includes the entire 1002 area (23 percent of the total subsistence land use area) (fig. II-8). The State lands along the coast west of the refuge are used during summer, often to Bullen Point and occasionally as far as Foggy Island Bay. Those and other State lands, though lightly used, account for 30 percent of the Kaktovik subsistence use area. Kaktovik Inupiat Corporation (KIC) lands adjacent to Kaktovik are the remaining 2 percent.

~ Participation in subsistence activities is a major aspect of Kaktovik residents' life. In 1978, 85 percent of Kaktovik households obtained all or most of their food supply from hunting, fishing, and gathering (J. W. Peterson, 1978, as summarized in Pedersen and others, 1985). More recent studies, also summarized by Pedersen and others

(1985), found that 80 percent of Kaktovik households daily consumed meats that were obtained from hunting and fishing. ~

Kaktovik residents depend mainly on caribou, Dall sheep, bowhead whales, fish, waterfowl, and other birds for subsistence (table II-4). Seals, polar bears, furbearers, and small game are also widely used, although they are not major components of the local diet. Brown bears and moose are occasionally taken. Many residents harvest berries, wild rhubarb, and roots. Driftwood is gathered from the beach and used to supplement oil heat, and willows are used for heating and cooking while camping.

Subsistence activities are most intensive during spring and summer months--the time of long hours of daylight, relatively mild weather, and species abundance. During the snow-free months, usually mid-June through September, overland travel is difficult. Shallow water prevents access to inland areas by river; however, by early July, coastal areas are accessible by small motorboats. From October through May, snow cover and frozen ground greatly expand the area used for subsistence hunting. Longer days, adequate snow cover, and milder weather make April and May the best months for snowmachine travel. Travel then extends across the tundra and to hunting camps along the Hulahula and Sadlerochit Rivers. During winter, foothills and mountain valleys are the most important places for subsistence hunting.



Table II-4.--Kaktovik participation in subsistence use, according to resource harvested.

[Of Kaktovik's 46 households, 21 were surveyed. Ten of the households not surveyed were teachers, or short-term residents, or without active hunters. NA, not available. Adapted from Pedersen and others, 1985]

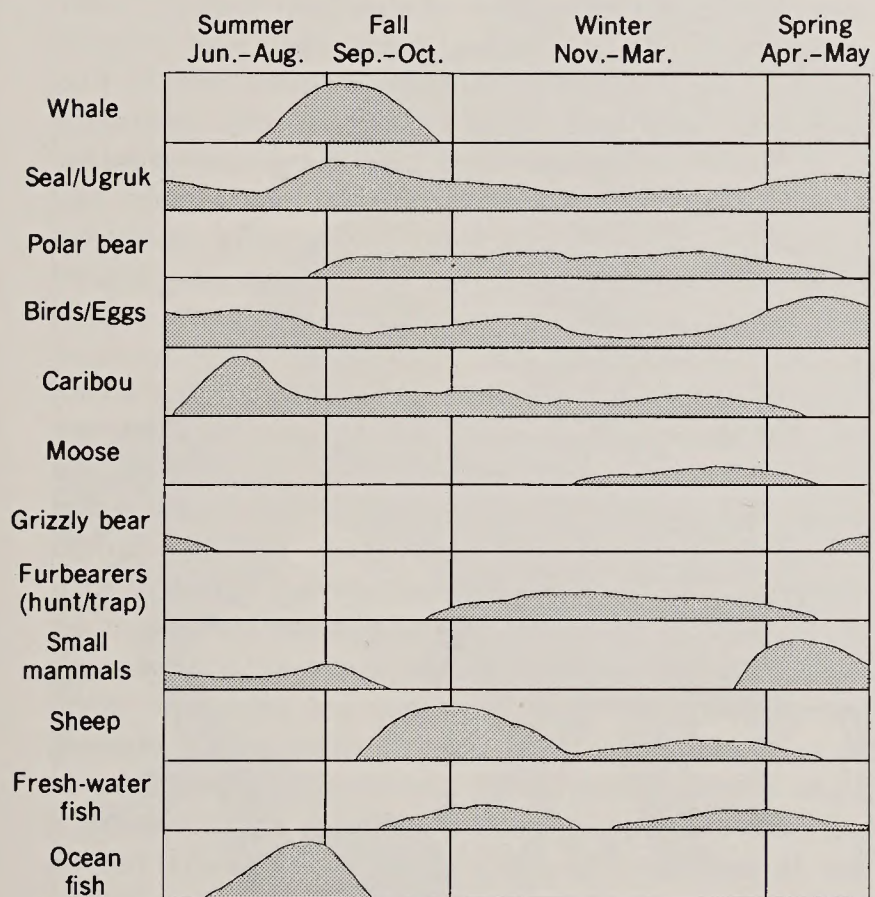


Figure II-7.--Yearly cycle of subsistence use by Kaktovik residents. Patterns indicate periods for pursuit of each species, based on abundance, hunter access, seasonal needs, and desirability. Modified from Jacobson and Wentworth (1982, p. 29).

Resource harvested	Participation (total 21)	
	Households	Percent
Fish.....	21	100
Caribou	20	95
Sheep.....	20	95
Wildfowl.....	20	95
Seals.....	19	90
Polar bears	18	86
Small mammals.....	18	86
Trapping furbearers.	16	76
Moose	16	76
Vegetation.....	15	71
Whales.....	14	67
Hunting furbearers	12	57
Grizzly bear.....	11	52
Walrus	6	29
Wood, fuel, and structural materials.....	5	24
Invertebrates	NA	--

Caribou is the staple land mammal in the Kaktovik subsistence diet. It is a source of fresh meat throughout the year, and is also frozen and dried. It is important in holiday feasts. Caribou hides are used for garments, boot soles, and blankets.

Caribou hunting and harvest are usually greatest from early July to late August, when they are hunted primarily along the coast from outboard-powered boats (pl. 2D). Other major hunting periods are late October to late November, when there is enough snow for overland travel by snowmachine and daylight is not too brief, and from late February through March and April, when daylight is longer and weather conditions are better.

Availability of the PCH to local hunters is highly variable. During the summers of 1978-81, the PCH migrated past Barter Island and into Canada before breakup of sea ice allowed Kaktovik people to travel by boat. Caribou from the CAH in the vicinity of the Canning River delta are especially important during such years. For 1972-84 the annual harvest was estimated at 40-300 caribou total, from both herds. More detailed studies in recent years show an annual harvest level of about 100 animals. The proportions of caribou harvested from the two herds varies: in 1981-82,

more than 80 percent of Kaktovik's caribou harvest was from the PCH; in 1982-83, about 70 percent was from the PCH; and in 1983-84, approximately half the community's harvest came from each herd (Pedersen and Coffing, 1984; Coffing and Pedersen, 1985).

Most winter caribou hunting occurs along river valleys in the mountains. Occasional hunting occurs on the coastal plain, especially at favored locations such as Konganevik Point. The Hulahula River valley is one of the most intensely used areas for winter caribou hunting; the Okpilak River and Okpirourak Creek drainages are also important winter-hunting areas. The Jago and Niguanak Rivers, the Niguanak Hills, and the Niguanak Ridge area immediately south are other winter-hunting areas.

In spring, caribou are hunted along the Hulahula, Sadlerochit, Okpilak, and Jago Rivers. The greatest expanse of hunting territory is covered at that time. Some trips are made up the Okerokovik River and to the foothill country of the Aichilik River. Occasionally, in late winter or early spring, people travel to the Canning River in the vicinity of Ignek Valley and Shublik Island and hunt caribou as far upriver as the Marsh Fork.

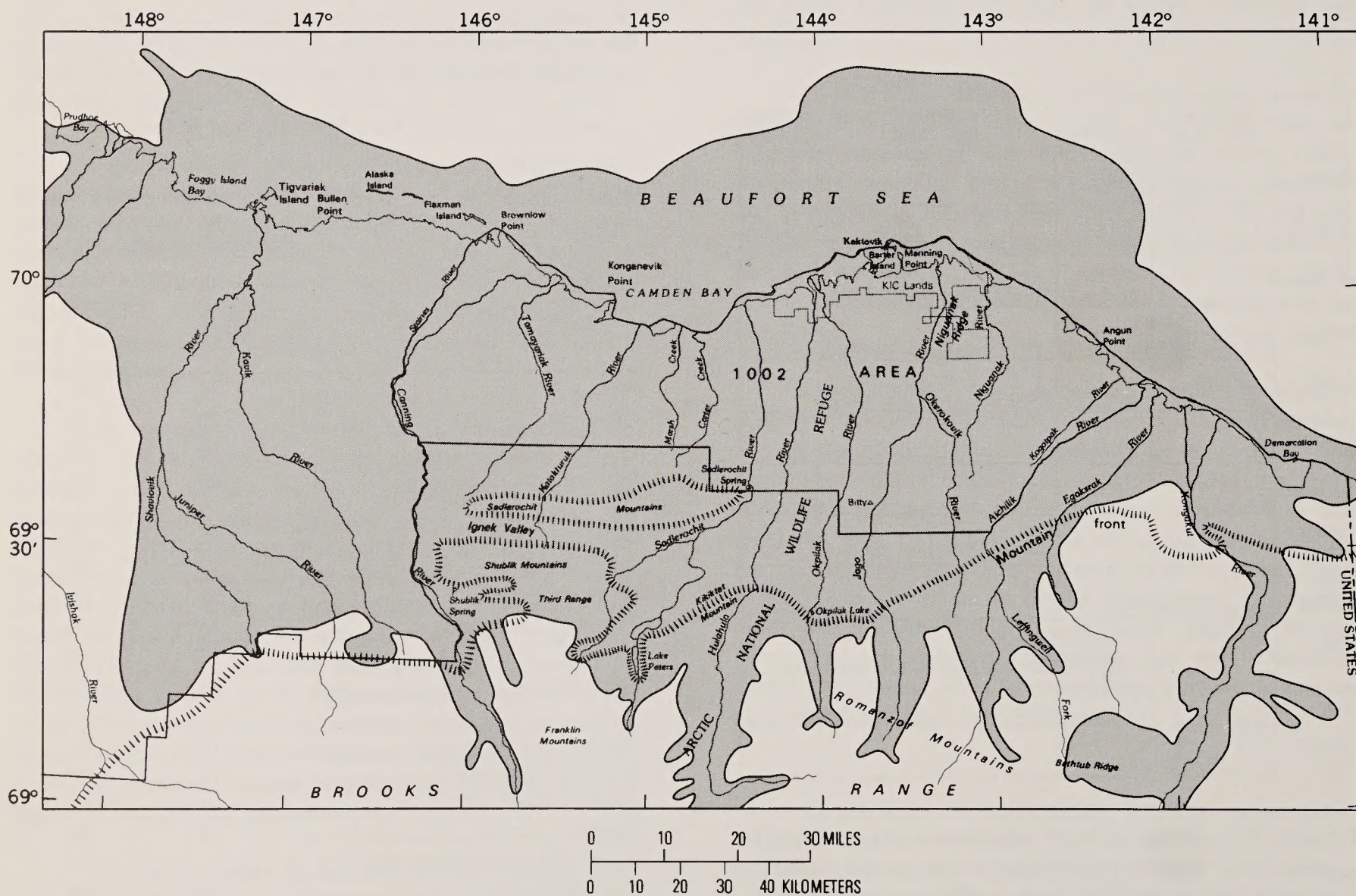


Figure II-8.--Extreme extent (pattered) of subsistence use by Kaktovik residents in the years 1923-83. Data from Pedersen, Coffing, and Thompson (1985).

Because they are rare within the 1002 area, Dall sheep are generally hunted outside the area, the hunting occurring from mid-October through March. The Hulahula River drainage within the mountains is hunted most extensively, beginning at the river's exit from the mountains near Fish hole 2 and continuing upstream to the headwaters. The Sadlerochit River, creeks along the eastern sides of the Shublik Mountains and Third Range, and the Whistler Creek area at Lake Peters are other locations where sheep are occasionally hunted. During recent years hunting has increased in the upper Okpilak, Jago, and, especially, the Aichilik River drainages (Jacobson and Wentworth, 1982).

The number of sheep taken by Kaktovik hunters has fluctuated greatly; only a few were killed in some years and as many as 50 in other years. The number of sheep killed is closely tied to the success of the whaling season and the number of caribou available for harvest. Snow cover, weather, and travel conditions in the mountains are also important factors. During 1982-84, Kaktovik hunters took only about half the 50 sheep for which they could obtain permits (Pedersen and others, 1985), mainly because of their success in procuring other resources.

~ According to older residents, Kaktovik was a prehistoric whaling site with whale bones used for a walkway to the beach. In the period of recorded history, though, no whaling occurred, perhaps because of unsuitable ice conditions and lack of equipment. Beginning again in 1964, whales (particularly bowheads and occasionally belugas) have been actively hunted. Whaling is viewed as one of the village's most important annual activities (Jacobson and Wentworth, 1982), expressing the cultural values of large group cooperation and sharing of resources, and being a way of passing these values to the younger generation. The harvest quota for Kaktovik, as determined through the cooperative agreement between the Alaska Eskimo Whaling Commission and the National Oceanic and Atmospheric Administration, has never been exceeded. Kaktovik hunters filled their quota of 3 whales in 1981. In 1981-85 an average of one whale was harvested annually, with an additional annual average of one whale struck and lost by the village. Approximately 22 whales were taken during 1964-81. Kaktovik's bowhead whaling season occurs during the westward migration of bowheads near the coast, from late August until early October. There is no spring whaling season in Kaktovik because the leads (open water channels) are too far from shore. Whales are generally hunted within 10 miles of land, but sometimes as far as 20 miles offshore from Barter Island. After a whale is butchered, the meat and muktuk (blubber and skin) are divided among the captain, crew, and the rest of the village.~

Kaktovik people hunt bearded, ringed, and spotted seals for oil, meat, and skins. Seals are hunted throughout the year and make an important contribution to the diet. Most seals are hunted from boats along the coast from July into September.

In recent years, most harvested polar bears were foraging on Barter Island, usually attracted by the remains of a beached whale or the Kaktovik landfill. They are actively hunted on the ice seaward of the barrier islands. The main hunting area for polar bears extends from the Hulahula-Okpilak River delta on the west to Pokok Lagoon on the east. Hunting is often best near decaying bowhead carcasses. Harvest varies considerably from year to year; as many as 28 were taken in the 1980-81 season, but an average of one bear has been taken annually since then (Schliebe, 1985; Jacobson and Wentworth, 1982; U.S. Fish and Wildlife Service, unpublished data).

Arctic char is the fish species most extensively used by local people. In early July, sea-run char are caught all along the coast, around the barrier islands, and along the navigable parts of the river deltas. Arctic cisco, the most commonly caught whitefish species, is taken in the ocean by netting or seining. Cisco begin appearing in the nets about mid-July near the peak of the arctic char run.

~ Willow and rock ptarmigan are hunted year-round, with greatest success during April and May. Waterfowl are hunted along the coast, mostly in the spring from May through early June, although less intensive hunting continues through the summer and into September. People usually hunt black brant, common and king eider, snow and Canada geese, pintail, and oldsquaw. More oldsquaw are usually taken than any other species, usually incidental to other forms of hunting or when fishing nets are checked. However, during July 1985-July 1986, 531 geese were harvested; most were brant. During that same period, people from Kaktovik harvested 251 ducks (S. Pedersen, ADF&G, unpublished data). A few bird eggs are collected each spring. ~

Winter is the season for trapping and hunting furbearers. Some Kaktovik residents hunt wolves and wolverines and trap red foxes in the foothills, chiefly south of the 1002 area. Others concentrate on arctic foxes on or near the 1002 area. Furs are used locally in making parkas and ruffs or are sold to the Village Corporation or to fur buyers.

Brown bears are taken by villagers strictly on an opportunistic basis (Jacobson, 1980), recently about two for the entire village per year. One or two moose are harvested each year by Kaktovik on an opportunistic basis. They are most often taken in the Sadlerochit Valley and in the foothills along Old Man Creek, Okpilak River, and Okpirourak River. Expanding muskoxen populations are a limited source of subsistence hunting. Arctic ground squirrels are hunted mainly from March through May along the banks and sandy mounds of the major rivers, especially the Jago, Okpilak, Hulahula, and Sadlerochit (Jacobson and Wentworth, 1982).

Several goals of the State-approved North Slope Borough Coastal Management Program (see "Coastal and Marine Environment") relate to subsistence resources. These goals are: (1) to protect the natural environment and its capacity to support subsistence activities; (2) to protect and enhance subsistence resources; (3) to preserve the Inupiat culture; and (4) to maintain and enhance access to subsistence resources.



~ OTHER COMMUNITIES ~

Several communities located relatively far from the Arctic Refuge utilize migratory species which may spend part of their life cycles in or near the 1002 area. Caribou are of particular significance, as well as snow geese, polar bears, and bowhead and beluga whales. Use of these migratory populations by other communities in Alaska and Canada is discussed below.

Caribou

Archaeological evidence indicates that people have been using caribou for at least 27,000 years, before the last glaciation in northern Alaska and Canada. Work done at sites occupied up to 1500 years ago near Old Crow, Yukon Territory, documented a subsistence economy centered on the interception of spring and fall migrations of caribou (Garner and Reynolds, 1986).

Today, harvest of caribou by communities in both Alaska and Canada depends largely on the variable distribution of the PCH from year to year. In some years, migration routes or wintering areas may not bring caribou near enough to a village to make hunting feasible. Still, the large amount of resources sharing and trading which occurs between villages reduces yearly variation between communities. The two villages other than Kaktovik that are most dependent on caribou using the 1002 area are Arctic Village, Alaska, and Old Crow, Yukon Territory; both are inland villages having little or no access to marine resources. Other communities whose residents hunt Porcupine caribou include Venetie, Fort Yukon, and Chalkyitsik in Alaska and Fort McPherson, Inuvik, Aklavik, Arctic Red River, and Tuktoyaktuk in the Northwest Territories.

Caribou is the most important food source for Arctic Village. Caribou from the PCH are usually available from August to April. Fall hunting is conducted near the village; winter hunting occurs farther away because snowmachines can be used. In the 1970's, the harvest at Arctic Village was reported to be 200-1,000 animals (LeBlond, 1979). Moose, fish, Dall sheep, waterfowl, and small mammals are also important, with an estimated 50 to 90 percent of all food consumed in the community derived from local wild resources (Caulfield, 1983).

Approximately half the food consumed by people in Old Crow comes from the land; of this, caribou is the most important. The major hunt for caribou is in the fall; some hunting occurs in winter and in spring depending on the year. In September, large numbers of caribou pass through the Old Crow flats and cross the Porcupine River en route to wintering areas. At this time they can be taken on land or by boat. Annual harvest of the PCH by Old Crow ranged from 250 to 1,000 between 1963 and 1986 (table II-5). People of Old Crow also harvest fish during the summer; moose, muskrats and waterfowl during spring; and rabbits and ptarmigan when available.

Other villages utilizing caribou from the PCH are located on the edge of the PCH range, and take caribou only in years when animals are available (U.S. Department of State, 1980). The estimated annual caribou harvest in Aklavik, Inuvik, Arctic Red River, and Fort McPherson, Canada, ranged from less than 100 to over 2,000 during 1963-86 (table II-5). Most of these animals are taken by the two communities of Aklavik and Fort McPherson (B. Pelchat, Yukon Wildlife Branch, and Don Russell, Canadian Wildlife Service, unpublished data). Alaskan villages of Venetie, Fort Yukon, and Chalkyitsik harvested 300-400 caribou in 1980-1981 (Pedersen and Caulfield, 1981). Sharing and trading of resources occurs between villages. If caribou are not available in Fort Yukon, for example, residents may trade salmon for caribou with residents of Arctic Village. Because of the well-established network of exchange, those who are unable to obtain subsistence resources for themselves are able to procure it from friends or relatives (Berger, 1977).

Use of Central Arctic Herd (CAH) caribou also occurs in communities other than Kaktovik. Residents of Nuiqsut, and some Barrow residents who travel to Nuiqsut for hunting, harvest caribou from both the CAH and Teshekpuk herd. The portion of the harvest from these respective herds is unknown (S. Pedersen, ADF&G, unpublished data). Residents from Anaktuvuk Pass harvest several hundred caribou annually from the Western Arctic herd, as well as some CAH animals. Through the harvest composition from each herd is not well known, it is believed that Anaktuvuk Pass residents rely primarily on Western Arctic herd animals, and harvest from the CAH is less than 100 animals (K. R. Whitten, ADF&G, unpublished data).

~ **Table II-5.**--Estimated Canadian harvest from the Porcupine caribou herd, 1963-86. ~

[Most of the estimates were obtained by conservation officers or biologists in the communities or by door-to-door interviews. Many figures are probably underestimates and reflect problems inherent in the data-collection methods. NA, not available]

Harvest year (12 mo)	Yukon Territory			Northwest Territories			Total Canada
	Old Crow	Dempster South ¹	Total	Akla- vik	Fort Mc- Pherson	Total	
1963-64	706	0	706	621	395	1,016	1,722
1964-65	769	0	769	774	492	1,266	2,035
1965-66	?	0	?	647	479	1,126	?
1966-67	592	0	592	477	479	956	1,548
1967-68	590	0	590	996	1,130	2,126	2,716
1968-69	557	0	557	541	742	1,283	1,840
1969-70	478	300+	778+	465	363	828	1,306
1970-71	450	300+	750	414	723	1,137	1,887
1971-72	485	250	735	616	250	866	1,601
1972-73	297	61	358	NA	NA	1,331	NA
1973-74	607	184	791	1,300	500	2,000	2,791
1974-75	382	24	406	NA	NA	1,331	NA
1975-76	785	29	814	NA	NA	NA	NA
1976-77	NA	239	NA	NA	NA	NA	NA
1977-78	537	29	556	114	350	564	1,120
1978-79	900	11	911	187	12	199	1,110
1979-80	800	44	844	147	168	315	1,159
1980-81	558	107	665	9	40	120	785
1981-82	1,000	42	1,115	300	1,500	1,800	2,915
1982-83	500	29	529	500	1,141	1,641	1,670
1983-84	1,000	100	1,100	NA	584	584	1,684
1984-85	250	37	287	---	1,500---	1,700	1,987
1985-86	349	543	892	---	1,570---	1,570	2,462

¹From Dempster Highway game check station. According to Don Russell (Canadian Wildlife Service, Whitehorse, Yukon Territory, March 1987), only a small proportion of this harvest is considered to be subsistence harvest.

Snow Geese

Birds from the Western Arctic snow geese population occur as fall migrants on the 1002 area. The major subsistence use of this species is in the coastal areas of the Northwest Territories of Canada near the major nesting colonies and fall staging areas, and along the Mackenzie River, a major spring and fall migration corridor. Subsistence harvest in spring and fall is important to the coastal communities of Aklavik, Inuvik, Tuktoyaktuk, Sachs Harbor, and Paulatuk, and the Mackenzie River communities of Fort McPherson, Fort Good Hope, Arctic Red River, Norman Wells, and Fort Norman (T. W. Barry and W. Spencer, Canadian Wildlife Service, unpublished data). Scanty data are available from some of these communities (table II-6). Snow geese do not appear to be an important subsistence resource in the northern Yukon community of Old Crow because they are not easily accessible there (J. Hawkings, Canadian Wildlife Service, unpublished data).

~ **Table II-6.**--Spring and fall subsistence harvest of snow geese in the Northwest Territories, Canada.

[Data available intermittently for 1967-85. From Barry (1985)]~

Community	1967		1968		1978	1985
	Spring	Fall	Spring	Fall	Spring	Spring & Fall
Tuktoyaktuk.....	2,162	1,158	---	---	4,348	3,500
Aklavik/Kendall						
Island ¹	144	280	---	845	---	---
Sachs Harbor.....	1,055	45	---	---	---	---
Paulatuk.....	---	---	335	56	---	---
Fort McPherson .	---	---	4	10	---	---
Arctic Red						
River.....	---	---	0	0	---	---

¹ Kendall Island is a hunting camp primarily used by Aklavik residents.

Polar Bears

In addition to harvest in or near the 1002 area by residents of Kaktovik, the Beaufort Sea population of polar bears is harvested by Inupiat Eskimos of other North Slope communities in Alaska as well as by communities in the coastal areas of Canada's Northwest Territories. These communities include Nuiqsut, Barrow, Wainwright, and probably Point Lay in Alaska, and Tuktoyaktuk, Aklavik, and Inuvik in the Northwest Territories. Sachs Harbor and Paulatuk, Northwest Territories, may harvest a small percent of their kill from bears of the Beaufort Sea stock, according to current satellite telemetry data (S. L. Schliebe, FWS, unpublished data).

~ **Table II-7.**--Alaska Beaufort Sea harvest of polar bears, 1980-87. ~

[From Schliebe (1987). Harvest year is July 1-June 30. 1986-87 data through January 1987. Only part of the Port Lay harvest is believed to be derived from Beaufort Sea stock]

Year.....	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87
Kaktovik.....	23	1	1	1	2	3	1
Nuiqsut.....	1	0	0	0	0	2	1
Barrow.....	6	4	13	27	31	12	14
Wainwright..	3	16	16	32	18	4	6
Point Lay.....	1	4	1	9	0	7	0

Harvest estimates for communities in Alaska utilizing the Beaufort Sea stock of bears are shown for the years 1980 through January 1987 (table II-7). Harvest in Canada is according to a quota system. Communities of Inuvik, Aklavik, and Tuktoyaktuk have a combined quota of 32 polar bears. The combined quota for communities of Paulatuk and Sachs Harbor, of which only a portion apply to the Beaufort Sea stock, is 39 (Taylor and others, 1987). Polar bears represent a substantial component of the cultural and economic base of the Inuit people of the Canadian Western Arctic. Hides have direct economic value, and in recent years the principal motivation for polar bear hunting has been the sale of hides (Stirling and others, 1975). Fur exports are an important source of cash in the economies of Mackenzie and "rim" villages. According to Brackel (1977), marine furs (white fox, polar bear, and ringed seal) provided 5 percent and 19 percent of the earned income in the Mackenzie and "rim" economies, respectively.

Whales

Inupiat residents of the community of Nuiqsut also harvest bowhead and beluga whales near the 1002 area. Although the community itself is not located on the coast, marine mammals are an important subsistence resource. Nuiqsut hunters in company with Kaktovik hunters sometimes hunt bowhead and beluga whales. Bowhead whaling usually occurs between late August and early October, the exact timing and length of the season depending on ice and weather conditions. The season may last between 2 weeks and 2 months. The bowhead is shared extensively with other North Slope communities and people as far away as Fairbanks and Anchorage. Whale baleen is bartered in traditional networks and is used in making traditional handicrafts (U.S. Minerals Management Service, 1986).

Beluga whales are harvested during the period of open water and are taken incidentally to the bowhead whale harvest in Nuiqsut (U.S. Minerals Management Service, 1986). Communities of the Mackenzie River delta (Inuvik, Aklavik, and Tuktoyaktuk) and Amundsen Gulf (Sachs Harbour, Holman, and Paulatuk), are also partially dependent on subsistence uses of beluga whales. Beluga whales are present in the Beaufort Sea north of the Arctic Refuge during spring and fall migrations where they generally follow the pack ice edge (Seaman and others, 1981). They are harvested in the Mackenzie part of the Beaufort Sea, where whales enter warmer waters of the bays near the Mackenzie River delta during early July and remain until the middle of August. Whaling for beluga near the Mackenzie delta is not regulated, and approximately 120 whales are taken per year (Brackel, 1977). Whale products are primarily used locally, although some products such as muktuk are occasionally sold. Beluga muktuk is often shared with relatives in Kaktovik and other Alaskan and Canadian villages. A variation in diet, and the sport and recreation of the hunt, with opportunities for socializing, are all important factors in whaling (Brackel, 1977).

LAND STATUS

~ Land ownership within and adjacent to the 1002 area is a complex of Federal, State, and private interests. Federally owned land to the south and east is managed as the Arctic National Wildlife Refuge. Oil and gas exploration has occurred on State lands west of the Canning River. Leases on 119 tracts totaling 592,142 acres of State lands west of the Canning River were offered January 27, 1987. Bids were received by the State on 26 tracts totaling 100,632 acres. ~

~ The Kaktovik Inupiat Corporation (KIC) has statutory entitlement to ownership of 92,160 surface acres within the Arctic Refuge north of the 1002 area. Subsurface ownership of these lands was conveyed to the Arctic Slope Regional Corporation (ASRC) by the United States under the terms of an August 9, 1983, agreement. The KIC/ASRC holdings are private lands; however, in accordance with section 22(g) of the ANCSA, these lands remain subject to the laws and regulations governing development of the Arctic Refuge. As such, oil and gas leasing and development cannot occur on the KIC/ASRC lands until authorized by an Act of the Congress (Section 1003 of ANILCA). ~

Submerged lands beneath the coastal lagoons in the area between the mainland and the offshore barrier islands from Brownlow Point to the mouth of the Aichilik River (with the exception of lagoons north of KIC lands) were included within the area of exploration authorized by section 1002(b)(1). The United States and the State of Alaska dispute ownership of these lands and have presented their arguments to a Special Master appointed by the United States Supreme Court. A final decision has not been rendered. Until this decision is made, all activity on these submerged lands requires concurrent Federal and State approval.

The State of Alaska has solicited comments and is developing a preliminary analysis for State offshore oil and gas lease sales, including submerged lands. Approximately 127,000 acres immediately offshore from the 1002 area between the Canning and Hulahula Rivers has been identified for a May 1987 State sale; about 300,000 acres offshore from the Arctic Refuge between the mouth of the Hulahula River and the Canadian border has been proposed for a May 1988 State sale.

~ Native allotments are scattered throughout the 1002 area, and are largely traditional use sites, such as campsites.

NATIVE ALLOTMENTS

~ Within the 1002 area, the Federal Government has begun to process toward conveyances some 25 applications, involving 34 parcels for Native allotments. None of these parcels had been issued a certificate of allotment as of January 1987. In total, these applications cover approximately 2,315 acres. A Native allotment is a parcel of land, containing 160 acres or less, which can be conveyed to a Native based on that individual's use and occupancy of the land under the authority of the Native Allotment Act, May 17, 1906 (43 U.S.C. 270-1), as amended August 2, 1956, and repealed by the Alaska Native Claims Settlement Act of December 18, 1971 (43 U.S.C. 1617). ~

Subsurface ownership under an allotment will be reserved to the government if it is determined that it may be valuable for coal, oil, or gas. The government or its lessee would then have the right to enter and use the lands for the development of the reserved minerals, subject to the duty to pay the allotment owner for damages to surface improvements and a bond to guarantee such payments. If the allotment area is known to be valuable for minerals other than coal, oil, and gas, an allotment is not granted.

INDUSTRIAL USE

There has been no industrial land use of the 1002 area other than oil and gas exploration under the 1002 program.

GOVERNMENT AND MILITARY USE

Arctic Contractors (PET-4 Contractor) established an exploration camp at Barter Island in 1947. The camp also supported the U.S. Coast and Geodetic Survey coastal surveying parties. Arctic Contractors constructed the airstrip in 1947.

~ The U.S. Air Force constructed a Distant Early Warning (DEW) Line Station (DEW Line Site BAR MAIN) on Barter Island in 1955 as part of a larger network of radar installations across the North American Arctic. In 1956 they built the DEW Line hangar adjacent to the airstrip. The establishment and expansion of the site forced the village

of Kaktovik to relocate three times, but also brought employment opportunities to villagers. The site is about 1/2 mile from the present village and is largely self-contained, functioning as an entity separate from the village. As many as 70 DEW Line employees live at the site, most of whom are hired from outside the North Slope. In 1986 the site employed three Inupiat and two non-Inupiat residents of Kaktovik. Modernization of the Bar Main DEW Line site started in 1986 when a new pad and tower were constructed. Testing new equipment will run through 1988, after which minor facility modification may be necessary. The Bar Main DEW Line site will continue to be staffed for at least the next 20 years. ~

The Alaskan DEW Line also included intermediate sites at Camden Bay (POWD) and Beaufort Lagoon (Humphrey Point, BAR A), which were constructed for communications relays. Advanced communications technology resulted in their deactivation in 1963. The lands (approximately 876 acres) formerly withdrawn for the two sites became a part of the Arctic Refuge on December 28, 1982.

State and Local Political and Economic Systems

Four levels of government operate within or affect the 1002 area: Federal, State of Alaska, North Slope Borough, and the village of Kaktovik. Two corporations, ASRC and KIC, have a major influence on private lands adjacent to the 1002 area. Many Native residents belong to and have direct input to the NSB, ASRC, KIC, and Kaktovik Village.

The State (1) establishes laws and regulations governing certain local activities, (2) provides financial and technical assistance, (3) exercises certain police and regulatory powers such as hunting and fishing bag limits and subsistence and commercial harvest of natural resources, and (4) sets standards for water quality.

The NSB was organized in 1972; in 1973 it was converted to a home-rule charter--the strongest form of local government under Alaska law (NSB, 1984a). The NSB has an elected mayor and an elected seven-member assembly. It is responsible (among other functions) for borough-wide planning such as the coastal management program, and it oversees the capital improvements program.

Kaktovik was incorporated as a second-class city in 1972, and has a council-mayor form of government. The mayor is appointed from the elected seven-member council.

The ASRC is the regional profit-making Native organization formed in 1972 under the provisions of the Alaska Native Claims Settlement Act (ANCSA). It is responsible to nearly 4,000 Inupiat stockholders for management of 5.6 million acres and \$75 million (ASRC, 1985; NSB, 1984b). ASRC owns subsurface rights for the entire 5.6-million-acre area and about 4.8 million surface acres scattered across the North Slope of Alaska.

KIC is a village corporation; it was formed under the provisions of ANCSA in 1972 to manage surface resources surrounding the village of Kaktovik that were transferred under the provisions of ANCSA and ANILCA.

~ Employment in the NSB increased from 977 jobs to 5,598 between 1970 and 1979. By September 1985, 9,234 workers were employed in the North Slope Borough; 86 percent of this employment was in the following major categories: mining, including oil development, 4,150 (45 percent); State and local government, 1,409 (15 percent); construction, 1,258 (14 percent); and services, 1,110 (12 percent). The remaining 14 percent were scattered in other smaller employment sectors (NSB Planning Department, 1986). The majority of jobs, principally at Prudhoe Bay and the military enclaves, are held by non-Native workers. However, participation by Inupiat in the labor market has been encouraged through NSB and ASRC programs. ~

The economy recently made a major transition from largely subsistence to mixed subsistence and cash. Through local-hire policies, the NSB has provided some employment for more than 50 percent of the resident Inupiat adults and has contributed significantly to increased per capita income. A major factor contributing to increased Native employment is the capital improvement program. However, long-term Inupiat employment opportunities depend on: (1) NSB's continuing ability to provide jobs; and (2) ability and desire of Natives to work at sites away from their homes.

The region has been isolated from the periodic boom-and-bust economic cycles of forest/fishery/gold extraction typical of other parts of Alaska. Except for whaling it remained virtually unchanged until after World War II. The primary driving force then became national defense (research at the Naval Arctic Research Laboratory at Barrow, and DEW radar sites along the coast). Today, the production of oil at Prudhoe Bay is the basic economic influence.

The State-approved NSB Coastal Management Program was described under "Coastal and Marine Environment." Of the goals relating to economic and government activities those particularly pertinent to this report are:

Preserve opportunities for traditional activities and the Inupiat way of life in the North Slope, regardless of ownership and jurisdictional boundaries,

Increase economic opportunity in villages,

Create employment for NSB residents which will provide flexibility for traditional Inupiat cultural and subsistence activities,

Develop new industries based on the Inupiat culture,

Protect life and property from natural hazards and phenomena,

Provide guidance and direction for present and potential resource development, onshore and offshore, including exploration, extraction, and processing and related facilities,

Cooperate and coordinate with private development,

Improve energy supply for local communities, and

Develop local energy resources.

PUBLIC SERVICES AND FACILITIES

~ Existing public services and facilities are described in the semiannual economic profile (NSB Planning Department, 1986). New oil and gas facilities assumed to result from existing offshore Federal leasing are described in scenarios for oil development in the Beaufort Sea (Roberts, 1987). ~

Air transportation is the single most extensive all-season form of travel in the region. Air facilities range from long, well-maintained paved runways to unimproved strips, sand bars, and local large lakes. During the winter oil and gas exploration is supported by artificially created ice strips. Commercial air transportation facilities are located at all communities in the NSB. Except for Barrow and Prudhoe Bay, most lack sophisticated navigation aids, lighting, and snow-removal equipment. The only military air facility of significance to the 1002 area is at Barter Island (Kaktovik), and is shared by the NSB and U.S. Air Force (NSB, 1984b). Originally constructed by the military, airstrips located at Camden Bay, Demarcation Bay, Beaufort Lagoon, and Bullen Point have been abandoned.

Marine transportation is controlled by ice conditions and shallow nearshore waters. Major port facilities are located at Prudhoe Bay. At Barter Island, shallow-draft vessels land directly upon the beach. Military sites have in the past been served by marine transportation. Most ports of embarkation are in Washington and California; only a small part of ocean freight is shipped from Alaska ports. The rivers in the 1002 area are too small and shallow for inland commercial navigation.

The Dalton Highway is an all-weather road connecting Prudhoe Bay to the Alaska highway system. No road network connects population centers in the NSB. Cross-country transportation to and from the 1002 area is limited to winter, using special equipment on the snow or sea ice. Nearly every community and military site in the NSB has an internal gravel or dirt road system linking air or marine transportation facilities. Village residents use motorbikes, three-wheeled all-terrain vehicles, cars, or trucks in summer, and snowmachines in winter.

The Trans-Alaska Pipeline System (TAPS) connects Prudhoe Bay and associated oil fields to a marine tanker terminal at Valdez, Alaska. Recent offshore sales by Federal and State Governments have been based on the assumption that feeder pipelines will connect any new commercial discoveries to the existing oil pipeline and that half those pipelines would be located onshore. Many factors including potential locations of production platforms and size of commercially developable fields are unknown. Possible offshore pipeline routes and landfalls include those suggested for Sales 71, 87, and 97. Of significance to the 1002 area is an assumed landfall at Bullen Point, west of the Canning River (Roberts, 1987).

~ The NSB provides water, sewage, sanitary, light-power-heating, public housing, education, health, and public-safety facilities in Kaktovik. At Kaktovik the school complex consists of a two-room elementary school and a high school with four classrooms, library, gymnasium, swimming pool, and kitchen. A vocational education building was completed in 1981. Junior and senior high school enrollment was 45 students as of January 1987. ~

Kaktovik has a health clinic staffed by a health aide. Two NSB Department of Public Safety Officers are stationed at Kaktovik. Federal facilities include the Post Office, the Arctic Refuge field office, and the Bar Main DEW site.

Archeology

Approximately 100 archeological sites are known within the 1002 area (pl. 1A). Dated sites appear to be comparatively recent and of either Historic Inupiat (approximately AD 1838-present) or Western Thule (about AD 900-1838) origin. Several smaller sites on the 1002 area--mostly scatters of lithic debris from the manufacture, maintenance, and use of stone tools--are not yet datable but may be considerably older.

Near the 1002 area sites have been dated to be as old as 6,000 years (U.S. Fish and Wildlife Service, 1982). A fairly widely accepted date from the Old Crow area of the Yukon Territory (about 150 miles southeast of the 1002 area) indicates that people have been present in the general area for the last 27,000 years. Even though sites of such an early period are few, sites 5,000-6,000 years old may occur on the 1002 area, but are yet to be discovered.

Archeological sites may occur almost anywhere in the 1002 area. However, some areas are much more likely to have sites, especially coastal areas and barrier islands. Most identified sites consist of the remains of sod houses, log cabins, burials, caches, lookout towers, and related features. Older sites may be buried under considerable sediment.

Archeological sites are also likely along rivers and streams that cross the 1002 area from the Philip Smith Mountains. These rivers could have provided fishing and would have been natural travel routes between the coast and the foothills. Sites known from the river courses are chiefly tent rings, although two interior sites have sod houses. Points of particular possibility are high, well-drained banks, especially near stream confluences.

Undiscovered sites may also be on high points of land that provide overlooks above the surrounding moist tundra; such spots are known to contain archeological sites throughout most of northern Alaska and Canada. There are relatively few such locations on the 1002 area, and sites that have been identified in such locations are uniformly small scatters of lithic material.

Archeological sites are even less likely on the relatively stable sandy areas in river deltas. As with the overlook sites, material from blowouts in deltas is currently limited to lithic remains.

The remainder of the 1002 area consists largely of flat to gently rolling tundra, now very wet. Such areas are least likely to contain sites, or to contain sites that are susceptible to discovery.

Recreation

Recreational use of the Arctic Refuge is varied and is related to wildlife or wilderness values. Types and amount of recreation are limited by the refuge's remoteness, harsh climate, and poor access. Fewer than 3,000 visits occur annually. Wet and moist ground conditions in the short summer season make surface travel difficult, and extended periods of cold and darkness during the winter reduce recreational uses at that time. Access is almost exclusively by aircraft and is costly. Nonetheless, recreational use of the 1002 area is slowly increasing as it becomes better known and as scheduled airline services to Barter Island improve.

The most common forms of recreation area are hunting, backpacking, and float trips on the larger rivers such as the Canning, Hulahula, and Aichilik. Other recreational pursuits are wildlife observation, photography, sightseeing, cross-country skiing, fishing, and nature study. Most recreationists pursue several of these activities. Kaktovik residents also engage in snowmobiling.

~ In 1986, 14 hunting guides operated on the refuge, though none guided on the 1002 area. Another 9 recreational guides conducted group float or backpack trips on the refuge. One or two guides operated recreational trips, at least in part, on the 1002 area during the past 5 years. Float-trip groups average 6-12 people. Figures on nonguided recreationists are unavailable, but probably fewer than 100 unguided visits occur annually on the ground in the 1002 area. Several hundred visitors fly over the 1002 area annually to sightsee or en route to other parts of the Arctic Refuge. ~

Wilderness and Esthetics

The Arctic Refuge is the only conservation system unit that protects, in an undisturbed condition, a complete spectrum of the arctic ecosystems in North America. Approximately 8 million acres of the refuge is designated as wilderness by ANILCA section 702(3), and adjoins the 1002 area on the south and east, including the coastal plain from the eastern 1002 area boundary to the Canadian border.

Wilderness is described by the Wilderness Act of 1964 (Public Law 88-557) as " * * * an area of undeveloped Federal lands retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value." With the exception of the two abandoned DEW Line sites on the coast, the entire 1002 area meets these criteria (Garner and Reynolds, 1986). The coastal plain in its present state has outstanding wilderness qualities: scenic vistas, varied wildlife, excellent opportunities for solitude, recreational challenges, and scientific and historic values.

~ The 1002 area is the most biologically productive part of the Arctic Refuge for wildlife and is the center of wildlife activity. It serves as an important calving ground for the Porcupine caribou herd; it contains a high percentage of the refuge's observed muskoxen range; it is an important fall staging area for lesser snow geese; it provides nesting habitat for waterfowl and shorebirds; and it is frequently used by denning polar bears from the Beaufort Sea population. Migrating caribou and the postcalving caribou aggregation offer an extraordinary spectacle. The area presents many opportunities for scientific study of a relatively undisturbed ecosystem. ~

Visual resources of the 1002 area encompass diverse ecotypes and landforms. The irregular coastline of the Beaufort Sea--characterized by its barrier islands, lagoons, beaches, submerged bars, spits, and river deltas--gives way to the south to the gently rising coastal plain. The backdrop of the steeply rising Brooks Range, with its deep river valleys and glacier-clad peaks, accents the abruptness and rugged beauty of the area.

~ Although the esthetic value of the 1002 area had been temporarily reduced as a result of seismic exploration, the area remains noteworthy and its wilderness values have not been diminished. Recent botanical studies show that recovery on the 1002 area is starting, with seismic trails less visible in the second year after disturbance (Felix and others, 1987). ~

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BRAIDED RIVER OF THE COASTAL PLAIN



LOW-CENTERED POLYGONS

CHAPTER III

ASSESSMENT OF OIL AND GAS POTENTIAL AND PETROLEUM GEOLOGY OF THE 1002 AREA

INTRODUCTION

This chapter presents the assessment of the oil and gas potential of the 1002 area of the Arctic Refuge. This assessment and the discussion of the petroleum geology of the 1002 area are based on surface geology studies and 1,336 line miles of seismic surveys (approximately a 3x6-mile grid) conducted by industry and the Department of the Interior. Although all seismic data were collected by industry, the analyses presented here are based on interpretations of that information by the U.S. Geological Survey (GS) and the Bureau of Land Management (BLM).

This chapter is organized as follows: first, significant results of the resource assessment are summarized; second, the geology of the 1002 area is briefly described, indicating the types of rocks and structures which might be present; third, the likelihood that oil and gas resources are present is assessed through the use of geological "play" analysis which leads to estimates of the amount of resource potentially beneath the surface of the 1002 area, without reference to its recoverability; and fourth, the possibility of recovering these potential resources is assessed by including technological and economic considerations.

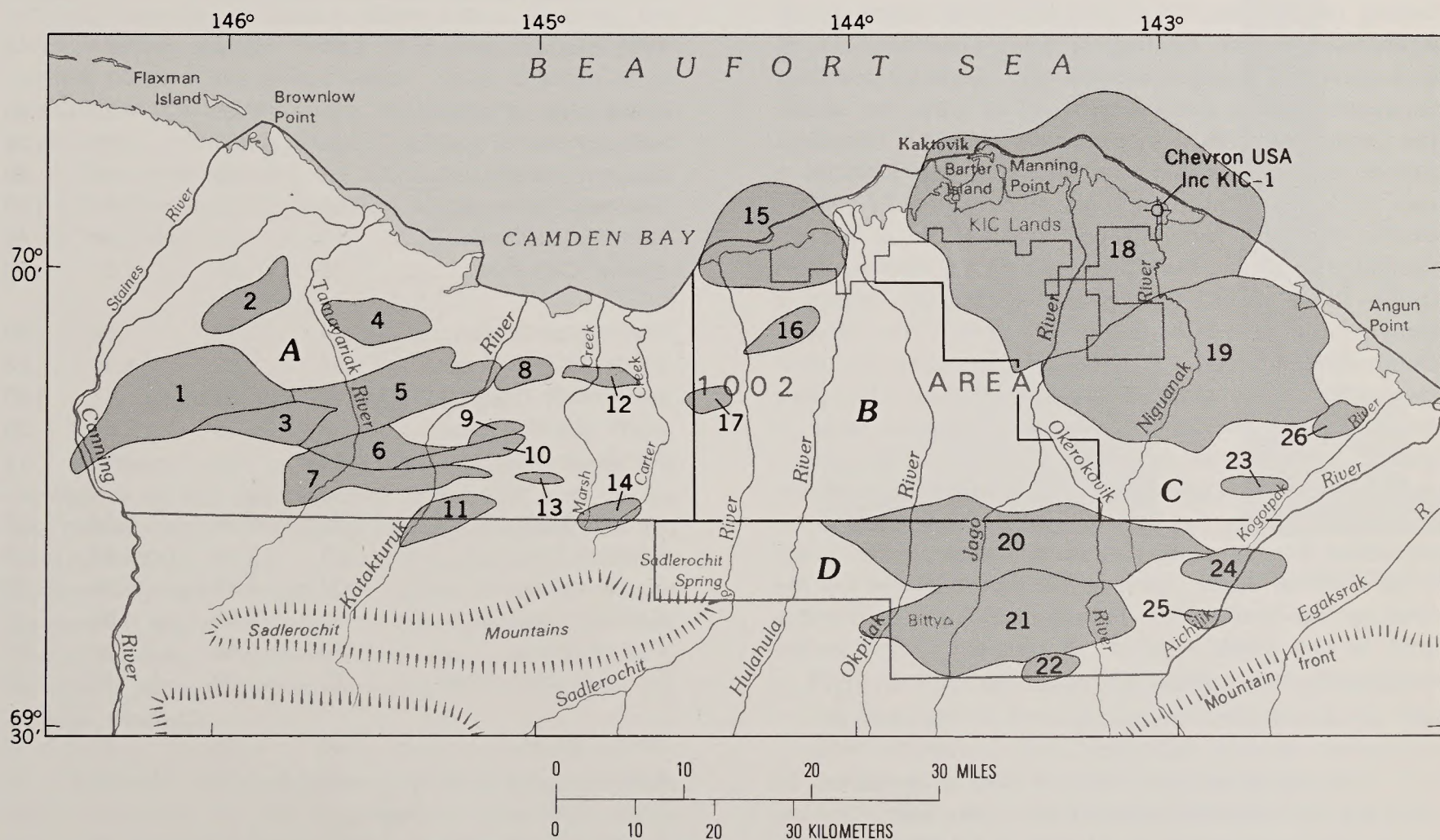


Figure III-1.--Seismically mapped prospects (1-26) and resource blocks (A-D) in the 1002 area.
(Prepared by the Bureau of Land Management.)

SIGNIFICANT FINDINGS AND PERSPECTIVES

The 1002 area is potentially rich in oil and gas resources. Seven different "plays" (areas with common geological characteristics favorable for oil and gas resource occurrence) were identified. From these plays, in-place resources were calculated. According to these estimates, there is a 95-percent chance the 1002 area contains more than 4.8 billion barrels of oil (BBO) and 11.5 trillion cubic feet of gas (TCFG) in-place, and there is a 5-percent chance that the 1002 area contains more than 29.4 BBO and 64.5 TCFG in-place. The average of all the in-place estimates made in this study, called the mean in-place estimate, is 13.8 BBO and 31.3 TCFG in-place.

Not all in-place resources are recoverable. To estimate the amount of the in-place resource which may be recoverable, 26 prospects were delineated and assessed (fig. III-1). These 26 prospects were subjected to petroleum engineering and economic considerations, resulting in estimates of economically recoverable resources. If there is economically recoverable oil present in the 1002 area (fields of more than 440 million barrels of oil, the chance of which is estimated to be about 19 percent), it is estimated that there is a 95-percent chance for more than 0.6 BBO and a 5-percent chance for more than 9.2 BBO recoverable in the area as a whole. The average of all the estimates of the conditional economically recoverable resources, the mean, is 3.2 BBO.

~ The statement that there is a 19-percent chance of finding recoverable oil in the 1002 area needs to be interpreted in the context of past experience in oil exploration and resource assessment. Generally speaking, the chance of oil's being present will be lower, the smaller the unexplored area being considered. The 19-percent chance for the 1.5-million-acre 1002 area thus indicates a very high potential when compared to the 27-percent chance for the 37-million-acre Navarin Basin or the 22-percent chance for the 70-million-acre St. George Basin (table III-1). Furthermore, the chance of finding a recoverable field will be lower, the greater the minimum economic field size. This occurs because, as past discovery statistics show, the number of fields of a given size is much lower for larger fields. There are fewer 1-billion-barrel fields than 100-million-barrel fields. Because of the high cost of operations in the Arctic, the minimum economic field size for the 1002 area is estimated to be 440 million barrels, an amount much higher than for areas in the lower 48 States. Despite this high threshold and the small acreage involved, the chance of finding a recoverable field in the 1002 area is 19 percent. This is an exceptionally high potential for oil and gas. ~

Gas was not included in the calculation of economically recoverable resources. Gas resources are unlikely to be economic in the 30-year time period being considered. Nevertheless, the gas resource estimated to be in-place is considerable, and would represent a major

addition to the Nation's gas resources. At some time in the future, this gas resource could become economic and benefit the Nation.

Table III-1.--Estimates of undiscovered, conditional, economically recoverable oil resources in the 1002 area and in Outer Continental Shelf (OCS) planning areas (unleased lands). For OCS planning areas, some of the reported marginal probabilities may be based on the probability of occurrence of commercial gas accumulations. For the 1002 area, only oil was considered.

[In billions of barrels. Data for OCS resources from Cooke (1985). MP_{HC} , the probability that economically recoverable oil resources occur somewhere in the area.]

Planning area	95-percent case	Mean case	5-percent case	MP_{HC}
1002 area	0.61	3.23	9.24	0.19
Central Gulf of Mexico ....	.95	2.66	4.97	1.00
Western Gulf of Mexico ..	.55	1.83	3.49	1.00
Eastern Gulf of Mexico ...	.03	.36	1.48	.99
Southern California .....	.58	1.22	2.01	1.00
Northern California .....	.15	.42	.76	.60
Central California .....	.18	.56	1.01	.65
Washington-Oregon .....	.04	.18	.54	.20
South Atlantic Ocean .....	.34	.82	1.46	.25
Mid-Atlantic Ocean .....	.07	.23	.47	1.00
North Atlantic Ocean .....	.18	.35	.54	.30
Florida Straits .....	.01	.04	.12	.11
Navarin Basin	1.81	3.28	5.09	.27
Beaufort Sea .....	.21	1.18	3.07	.70
St. George Basin .....	.37	1.12	1.98	.22
Chukchi Sea .....	.96	2.68	4.88	.20
Gulf of Alaska .....	.12	.49	.86	.08
North Aleutian Basin .....	.08	.36	.76	.20
Norton Basin .....	.05	.28	1.02	.12
Kodiak .....	.04	.15	.26	.05
Hope Basin .....	.13	.17	.40	.02
Shumagin .....	.05	.05	.09	.03
Cook Inlet .....	.03	.18	.40	.04

~ One way to assess the oil potential of an area is to compare estimates of the amount of oil in that area with the estimates for other areas. Table III-1 shows the conditional economically recoverable resource estimates for the 1002 area and for the Outer Continental Shelf planning areas. The table also shows the marginal probability (MP_{HOC}) that economically recoverable resources exist in each area--in other words, the probability that the "condition" on which the conditional resources are based is true. If the conditional resource estimates are adjusted for their respective marginal probabilities, the 1002 area ranks sixth out of all the areas, with three of the higher five already in production. Consequently, these estimates show that the 1002 area is one of the most outstanding prospective oil and gas areas remaining in the United States. ~

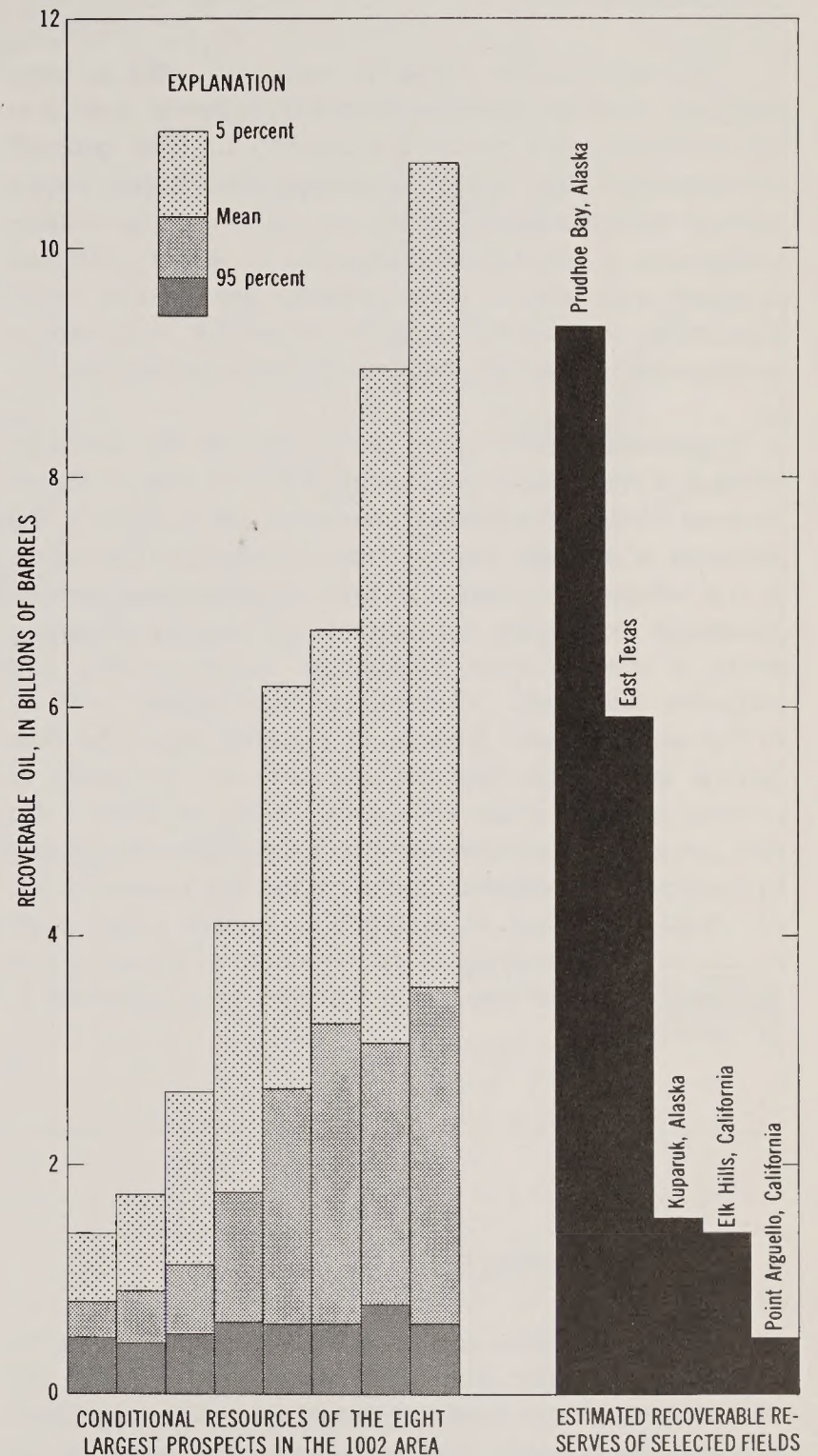
An area's potential can also be assessed by examining the individual prospects identified within the area. Figure III-2 shows the conditional resource estimates for the eight largest 1002 prospects in comparison with the largest known fields in the United States. If recoverable resources are present, the two largest prospects each have a 5-percent chance of at least equaling the size of Prudhoe Bay; the next two largest prospects each have a 5-percent chance of rivaling the East Texas field; and the next four each have a 5-percent chance of exceeding fields such as Kuparuk, Elk Hills, and Point Arguello. The probability that any one of these prospects has economically recoverable resources is less than the overall area-wide probability of 19 percent. Although the chance of discovering a field of 10 billion barrels, or even 1 billion barrels, is small, the chance is far greater in the 1002 area than in other onshore areas of the United States. Such chances of an enormous discovery indicate a very attractive area for oil exploration. For perspective, in 1982, 1,402 new-field discoveries were reported for the United States, but only 652 million barrels of hydrocarbon liquids were discovered in the new fields.

SUMMARY OF METHODS

Methods used in estimating potential in-place and recoverable oil and gas resources in the 1002 area rely on two related techniques using similar components of the geologic data base. Each assessment depends fundamentally upon recognition of potential petroleum traps (prospects) and description of their geologic and fluid characteristics. Particular care was taken to ensure consistent data treatment, honoring information from the geologic studies.

Generally, the assessment of in-place resources deals with prospects in the aggregate. The recoverable resources assessment deals with separate assessments of the larger (or selected) prospects which are then aggregated. Estimation of in-place resources includes both

identified prospects and those estimated to exist on the basis of geologic setting. This includes both structural and stratigraphic traps. However, estimating of recoverable resources was limited to those prospects (all structural) which can be identified and delineated with a reasonable degree of certainty, and which are physically large enough to reasonably be expected to contain commercial quantities of oil.



~ **Figure III-2.**--Conditional, economically recoverable oil resources of the eight largest prospects in the 1002 area compared with estimated ultimate recoverable reserves of five known producing fields. The recoverable resources are modified from McCaslin (1986, p. 318-319). The geologic probability of a significant oil occurrence in the eight prospects ranges from 3 to 10 percent. ~

Sedimentary Rocks

~ The separate methods used meet specific requirements of the 1002 area study. First, assessment of the natural endowment of hydrocarbon resources is met by assessing what is in-place, employing a broad-based view without economic constraints. Second, a site-specific evaluation of what may be a recoverable resource at a given prospect is made, taking into consideration economics, technology, and transportation under various assumptions. This recoverable estimate is then used to develop scenarios, impact assessment and national need determinations. ~

Assessment of in-place resources used a "play analysis" method whereby prospects (potential petroleum accumulations) are grouped according to their geologic characteristics into "plays" or natural associations having common characteristics. In the assessment of recoverable resources, a site-specific analysis of larger individual prospects was used in order to model the elements which determine recoverability and determine exploration, development, production, and transportation at that level.

~ Estimating either oil or gas in-place or the extent to which it is recoverable in an undrilled frontier area is difficult because of the uncertainties inherent in the process. The existence of potential hydrocarbon formations or prospects is not known with certainty prior to exploratory drilling. Information concerning the existence of potential producing fields is derived from inferences, extrapolations and subjective judgments. Geophysical data provide clues as to the existence and location of possible traps and their general dimensions, but geologic data on the quality of potential reservoir rocks are usually absent or limited. No data are available on the nature and distribution of included hydrocarbons or whether hydrocarbons are present at all. An exact prediction of resource quantities under such conditions of uncertainty is impossible because the uncertainties in the input data translate to uncertainties in the answers. ~

PETROLEUM GEOLOGY

The 1002 area of the Arctic Refuge lies along the foothills and coastal plain north of the Brooks Range (fig. III-3). Much of this area is covered by soil or vegetation, and the few outcrops that are present are mostly of the younger part of the stratigraphic sequence. Our knowledge of the geology of the area is based on these few outcrops, extrapolating known geology of adjacent areas, and integrating this with the geophysical data (mainly seismic surveys) acquired within the 1002 area. This section reviews the overall geology, emphasizing those aspects that relate to petroleum geology. More detailed and technical discussions of the geology, geophysics, and assessment methods are contained in GS Bulletin 1778 (Bird and Magoon, 1987).

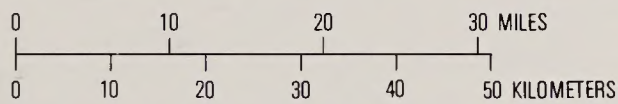
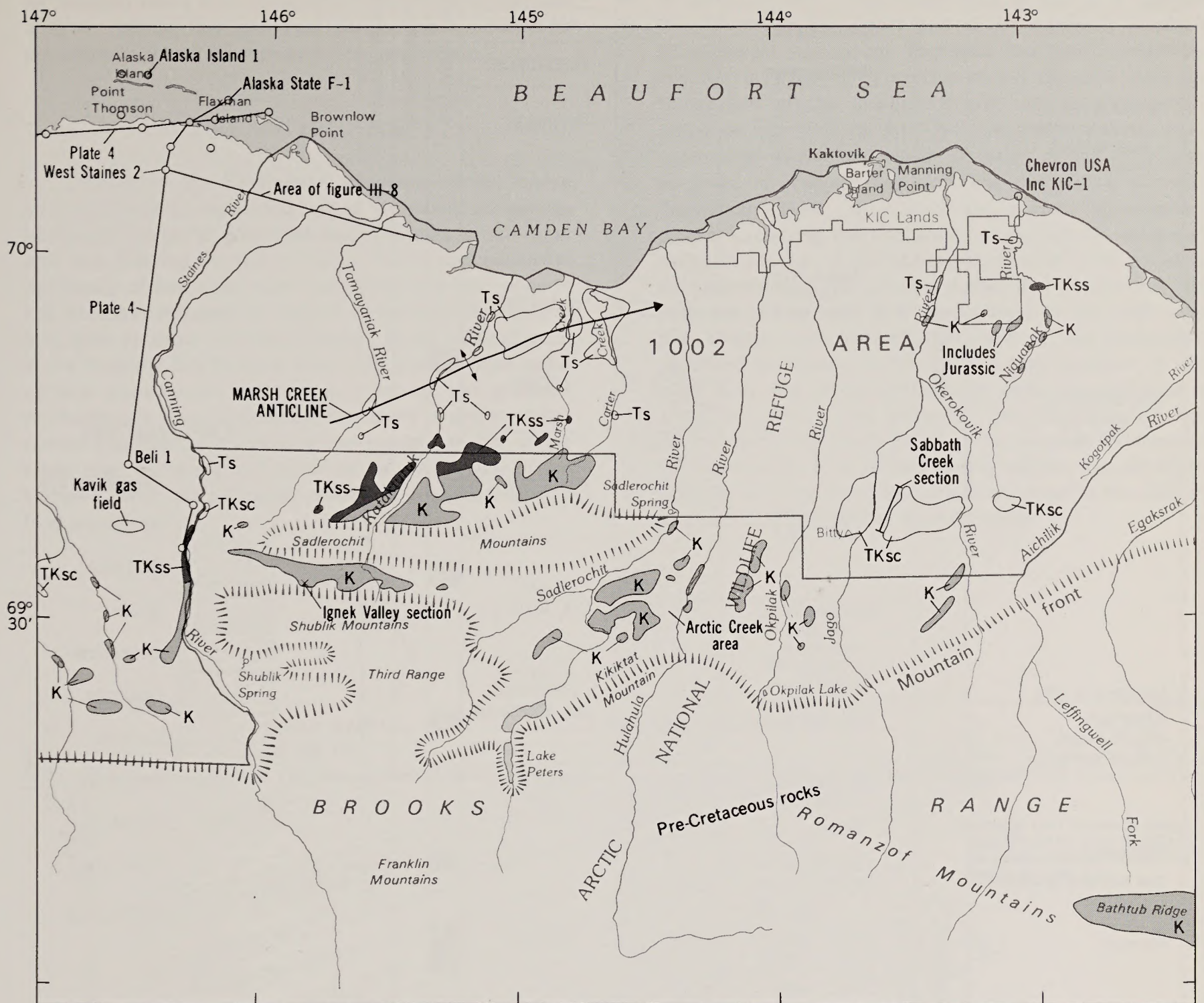
The area in and adjacent to the 1002 area is underlain by sedimentary rocks several tens of thousands of feet thick. These rocks range in age from Precambrian (greater than 570 million years old) to Quaternary (Bader and Bird, 1986). In northern Alaska, rocks prospective for petroleum (oil and gas) are mostly Mississippian to Tertiary in age and overlie folded and truncated pre-Mississippian rocks. These rocks are divided into two sequences: the Ellesmerian sequence of Mississippian to Early Cretaceous age, and the Brookian sequence of Early Cretaceous and younger age. Deposition of the Ellesmerian sequence occurred when the land area was to the north and the seaway was to the south. During deposition of the Brookian sequence, the geography was reversed--the land area was to the south (the ancestral Brooks Range) and the seaway was to the north, much as it is today. The differentiation of these two sequences is important in understanding depositional history, and in projecting trends of reservoir rocks. Furthermore, reservoir properties of the Ellesmerian sandstones are generally better than those of the Brookian sequence.

Figure III-4 is a generalized stratigraphic column of the rocks in the area, showing oil-bearing formations west of the 1002 area, potential source rocks, and significant geologic events. The following discussion summarizes pertinent information on the sedimentary rocks relating to the oil and gas assessment and reviews their depositional history.

PRE-MISSISSIPPIAN ROCKS (BASEMENT COMPLEX)

Pre-Mississippian rocks in the mountains adjacent to the 1002 area consist of more than 20,000 feet of a variety of rock types such as phyllite, argillite, quartzite, chert, and volcanic and carbonate rocks, and are mostly of Precambrian age. Because most of these rocks are weakly metamorphosed and are not prospective for petroleum, they are considered to be economic basement and are not discussed further. However, the carbonate rocks--limestone and dolomite--might contain porous zones that could serve as reservoirs for oil or gas that may have been generated in overlying younger rocks. These conditions apparently exist in the Exxon Alaska State F-1 and Sohio Alaska Island 1 wells on the barrier islands north of Point Thomson (fig. III-3), where oil and gas have been recovered from carbonate rocks in the basement. Similar situations may occur in the 1002 area, and these rocks are important to the petroleum assessment.

At least 6,500 feet of carbonate rocks, ranging in age from Precambrian(?) to Devonian and known as the Katakaturuk Dolomite and Nanook Limestone, crops out in the Sadlerochit and Shublik Mountains. Unnamed carbonate rocks as much as 200 feet thick have been penetrated in a few wells in the Point Thomson area. Their distribution in the subsurface of the 1002 area is unknown, because they had been folded and eroded prior to



EXPLANATION

Ts	Tertiary sedimentary rocks
	Paleocene and uppermost Cretaceous sedimentary rocks
TKsc	Shallow marine and nonmarine sedimentary rocks and conglomerate
TKss	Deep-water marine sandstone and shale
K	Cretaceous sedimentary rocks
○	Drill hole

Figure III-3.--Map of the 1002 area and adjacent mountains showing locations of Cretaceous and Tertiary outcrops and lines of sections of figure III-8 and plate 4. (Prepared by the U.S. Geological Survey.)

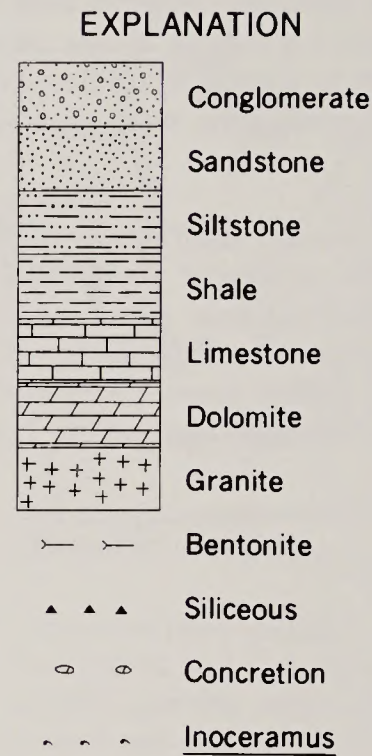
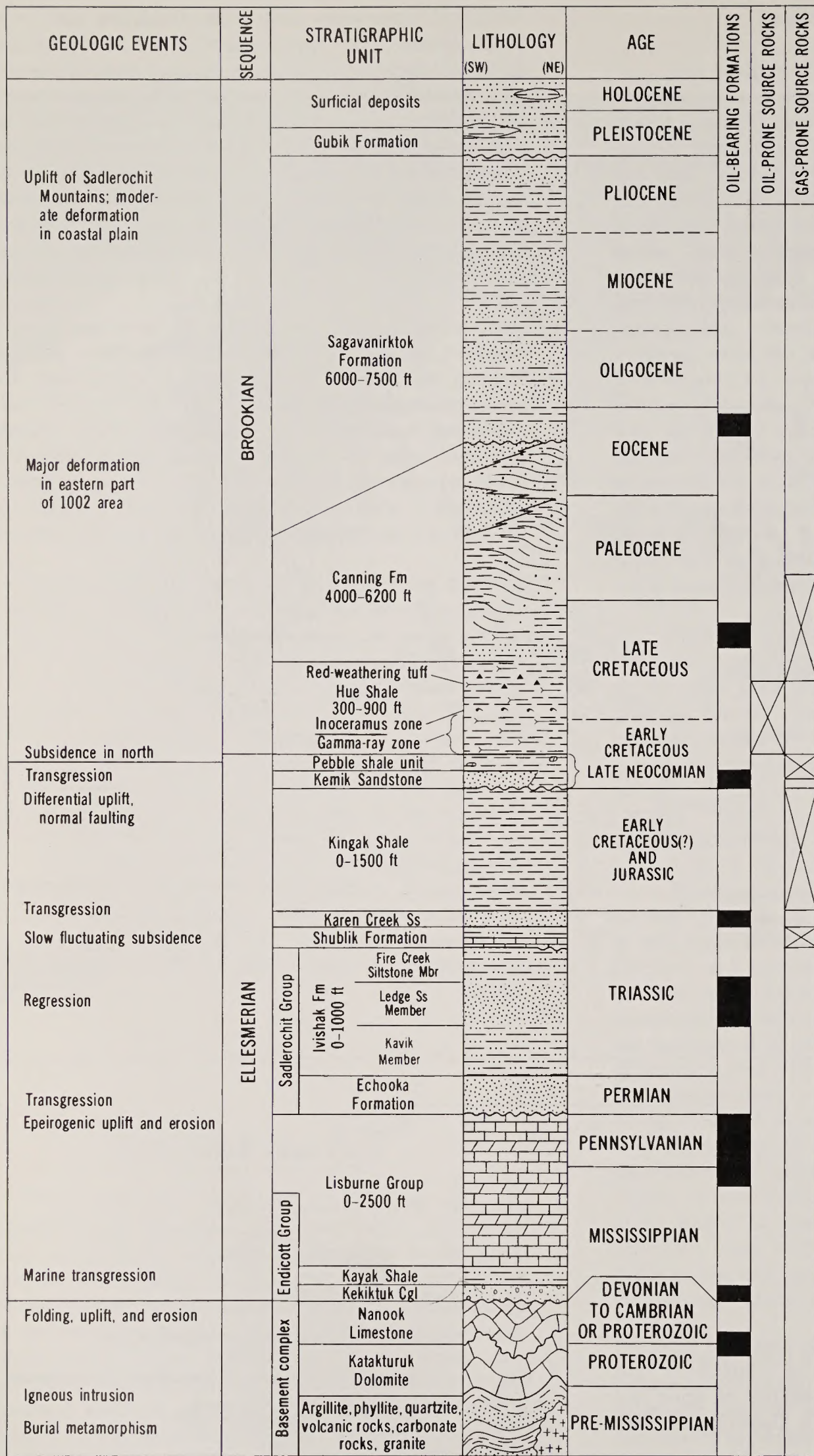


Figure III-4.--Generalized stratigraphic column for the 1002 area showing significant geologic events, oil-bearing formations west of the Arctic Refuge, and potential source rocks. The Hue Shale may range into the Paleocene in parts of this area. (Prepared by the U.S. Geological Survey.)

deposition of Mississippian and younger strata. Seismic reflections beneath these younger strata are not adequate for mapping these older carbonate rocks without closer well control. Hence, their presence as possible reservoirs for petroleum is risked accordingly in the assessment.

ELLESMERIAN SEQUENCE

Rocks of the Ellesmerian sequence record marine and nonmarine deposition along a slowly subsiding continental margin in which the land area was to the north and the seaway to the south. These rocks consist dominantly of limestone, shale, and sandstone that range in age from Mississippian to earliest Cretaceous (fig. III-4), a time span of about 210 million years. All the oil production in the Prudhoe Bay-Kuparuk River field areas is from rocks of the Ellesmerian sequence. By far the greatest production is from the Ledge Sandstone Member of the Ivishak Formation, but almost all the sandstone units of the Ellesmerian sequence and some of the carbonates of the Lisburne Group are potentially productive in some fields (fig. III-4).

In and adjacent to the 1002 area, the Ellesmerian sequence ranges in thickness from a few hundred feet to about 5,000 feet. This wide range is due to a regional unconformity in the upper part of the sequence in which progressively more of the sequence had been removed by erosion in a north or northeastward direction prior to deposition of the uppermost part of the Ellesmerian sequence (fig. III-5; pl. 4). This unconformity is of great importance to the petroleum potential of the 1002 area because it controls the northern distribution of most Ellesmerian rocks. In addition, the porosity of reservoirs directly underlying the truncated surface may be enhanced owing to solution of calcite cement, and the shale overlying the unconformity may provide a seal and source rock for truncated reservoirs. Well control west of the 1002 area and seismic data indicate that most of the Ellesmerian sequence is missing in the northwestern quadrant of the 1002 area (fig. III-6), but seismic data suggest that a significant part of the sequence may be present in the eastern part of the area (pl. 5). The presence or absence of these rocks in that area greatly affects the petroleum potential because very large structures occur in the eastern and southeastern parts of the 1002 area.

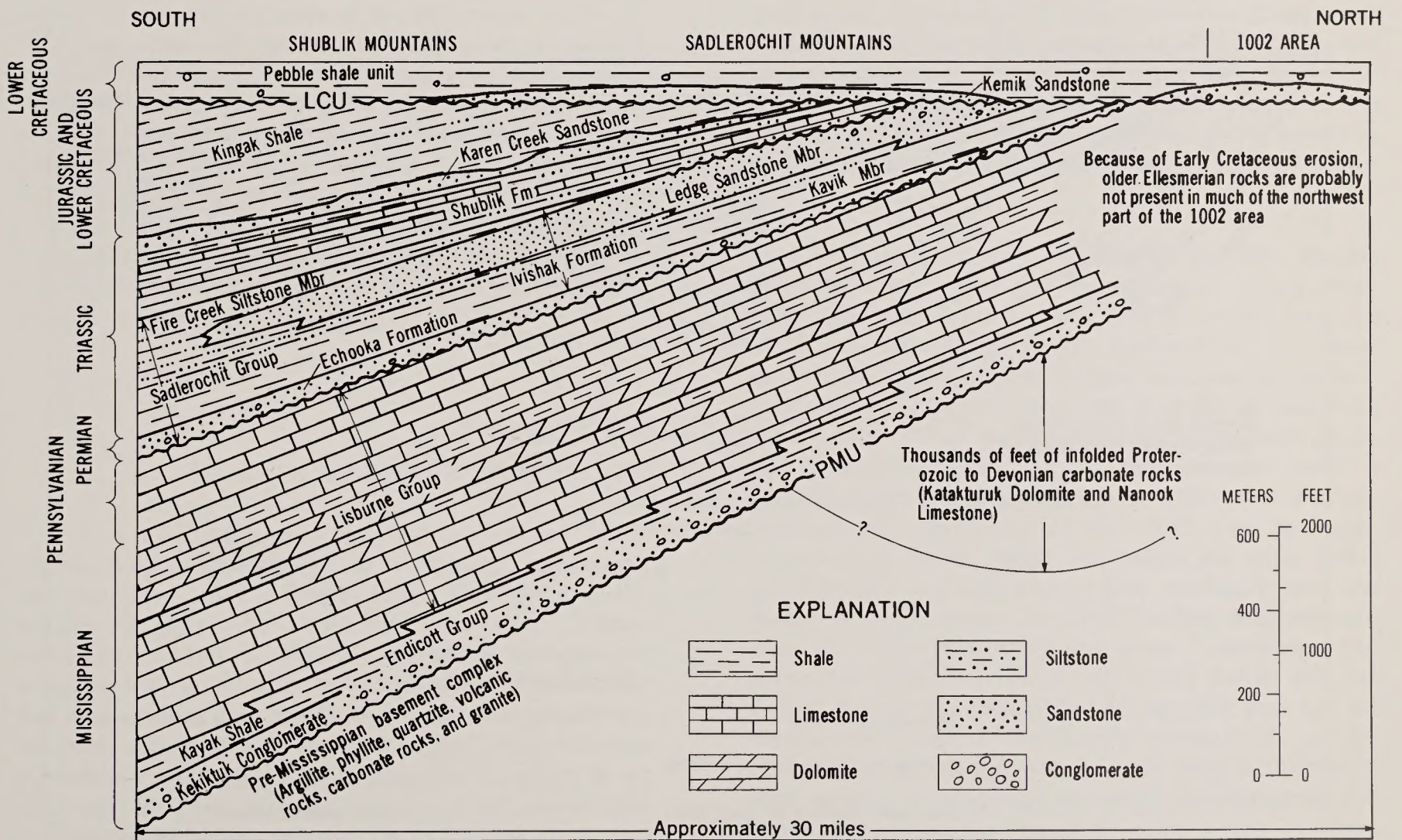


Figure III-5.--Diagrammatic section showing stratigraphic relations of the Ellesmerian sequence along the mountain front south of the 1002 area. (Prepared by the U.S. Geological Survey.)

Maps showing the known trends and thicknesses of three of the main Ellesmerian potential reservoir rocks of the 1002 area in figure III-7 are based on outcrop and well control.

DEPOSITIONAL HISTORY

Following a period of deformation (folding and faulting), uplift, and erosion of pre-Mississippian rocks, the Ellesmerian sequence was deposited on an erosion surface of slight relief. Initial deposits of sand, gravel, mud, and peat filled in low areas and built up on a coastal plain as the seaway advanced from the south. These deposits became the sandstone, conglomerate, shale, and coal of the rock unit called the Kekiktuk Conglomerate, which is less than 400 feet thick in areas adjacent to the 1002 area. As the sea advanced northward, a few hundred feet of offshore muds accumulated that formed the Kayak Shale. As the sea advanced farther and the land area to the north subsided, less sand and mud washed into the seaway or basin. Lime muds and fragments from lime-secreting organisms then accumulated in substantial thicknesses to form the limestone and dolomite of the Lisburne Group.

Then, probably in Late Pennsylvanian and Early Permian time, the entire North Slope area was uplifted and subjected to erosion. In areas adjacent to the 1002 area, the remaining Lisburne Group is 1,500 to 2,000 feet thick (fig. III-7A).

In Late Permian time and continuing into the Early Triassic, the area was once again inundated by the sea while sand, gravel, and mud were washing into the sea from a rising northern landmass. Initially, sands and gravels were deposited along the shoreline of the advancing sea. These formed the Echooka Formation, which is 50 to 400 feet thick adjacent to the 1002 area. Later, as the sea advanced farther, offshore muds were deposited until deltaic and offshore shelf deposits of sands and lesser amounts of gravels filled in or pushed the seaway back again. Then either the northern source area was worn down or the sea advanced northward again and more offshore muds were deposited. All these deposits make up the Ivishak Formation, which is further divided (in ascending order) into the Kavik Member (a shale unit made up of the lower offshore muds), the Ledge Sandstone Member (formed from the deltaic and shelf sands), and the Fire Creek Siltstone

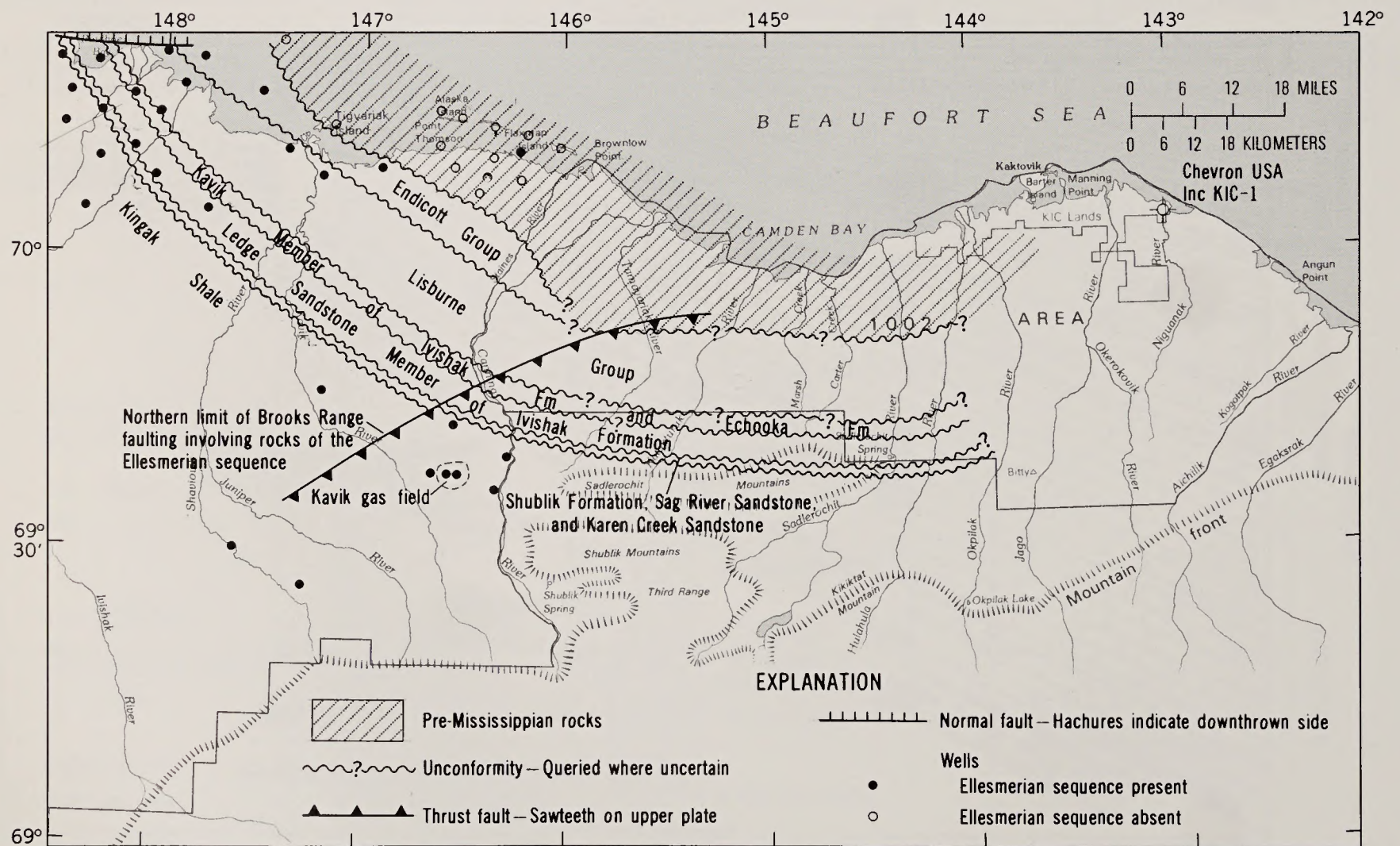


Figure III-6.--Map summarizing the northern limits of the Ellesmerian potential reservoir rocks preserved under the Lower Cretaceous unconformity. (Prepared by the U.S. Geological Survey; based on regional control.)

Member (formed from the upper offshore muds). The Ledge Member is 200 to more than 400 feet thick (fig III-7B) and is the main producing reservoir at the Prudhoe Bay field. The Ivishak and Echooka Formations together make up the Sadlerochit Group.

Continued subsidence of the basin followed Sadlerochit deposition, and offshore muds and chemical sedimentation predominated in a sea rich in organisms in Middle and Late Triassic time. This formed the black shales, siltstones, and dark phosphatic fossiliferous limestones of the Shublik Formation, which is 150 to 500 feet thick adjacent to the 1002 area. The Shublik is considered to be an important source rock for Prudhoe Bay oil. A minor regression or increase in clastic input from the northern source resulted in deposition of widespread silt and fine sand on a broad shelf, which formed the 10- to 125-foot-thick Karen Creek Sandstone.

The basin subsided during Jurassic and earliest Cretaceous time and thick deposits of mud accumulated on the shelf, basin slope, and basin bottom. These muds make up the Kingak Shale, which, after subsequent erosion, is 0-1,200 feet thick adjacent to the 1002 area. Parts of the Kingak are thought to contain enough organic matter to be a source rock for some of the Prudhoe Bay oil and gas.

Uplift of northernmost Alaska and the offshore area to the north in Early Cretaceous time resulted in removal by erosion of progressively more of the Ellesmerian section to the north. This was followed by subsidence of the area and northward inundation by the seaway again. Lenticular sands were deposited along the advancing shoreline and offshore shelf, and mud was deposited farther offshore. These deposits formed the Kemik Sandstone, as much as 100 feet thick, the Thomson sand, as much as 345 feet thick (fig. III-7C), and the pebble shale unit, 200-300 feet thick. Deposition of the Ellesmerian sequence ended as the northern land area subsided and was never again a sediment source.

BROOKIAN SEQUENCE

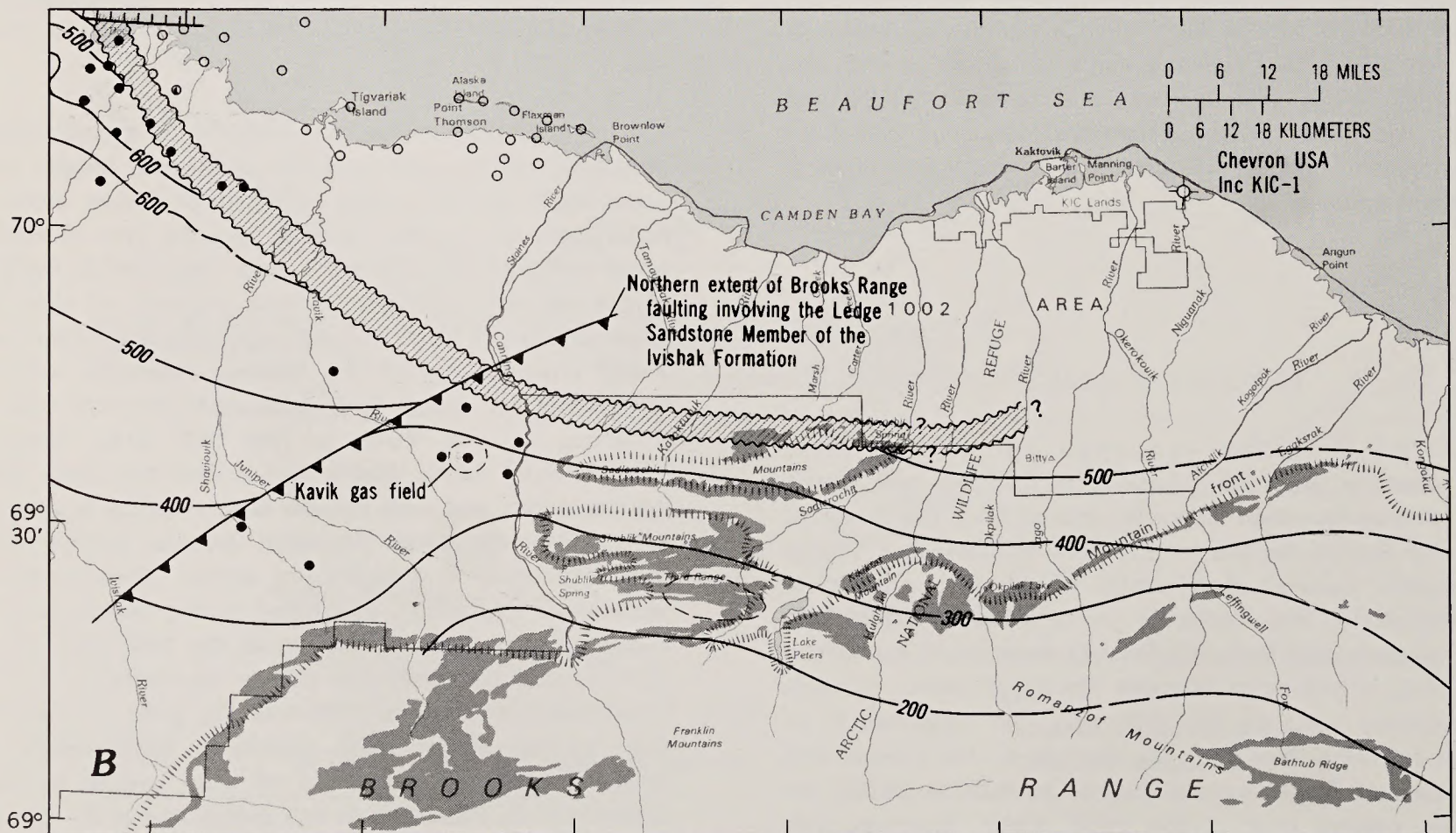
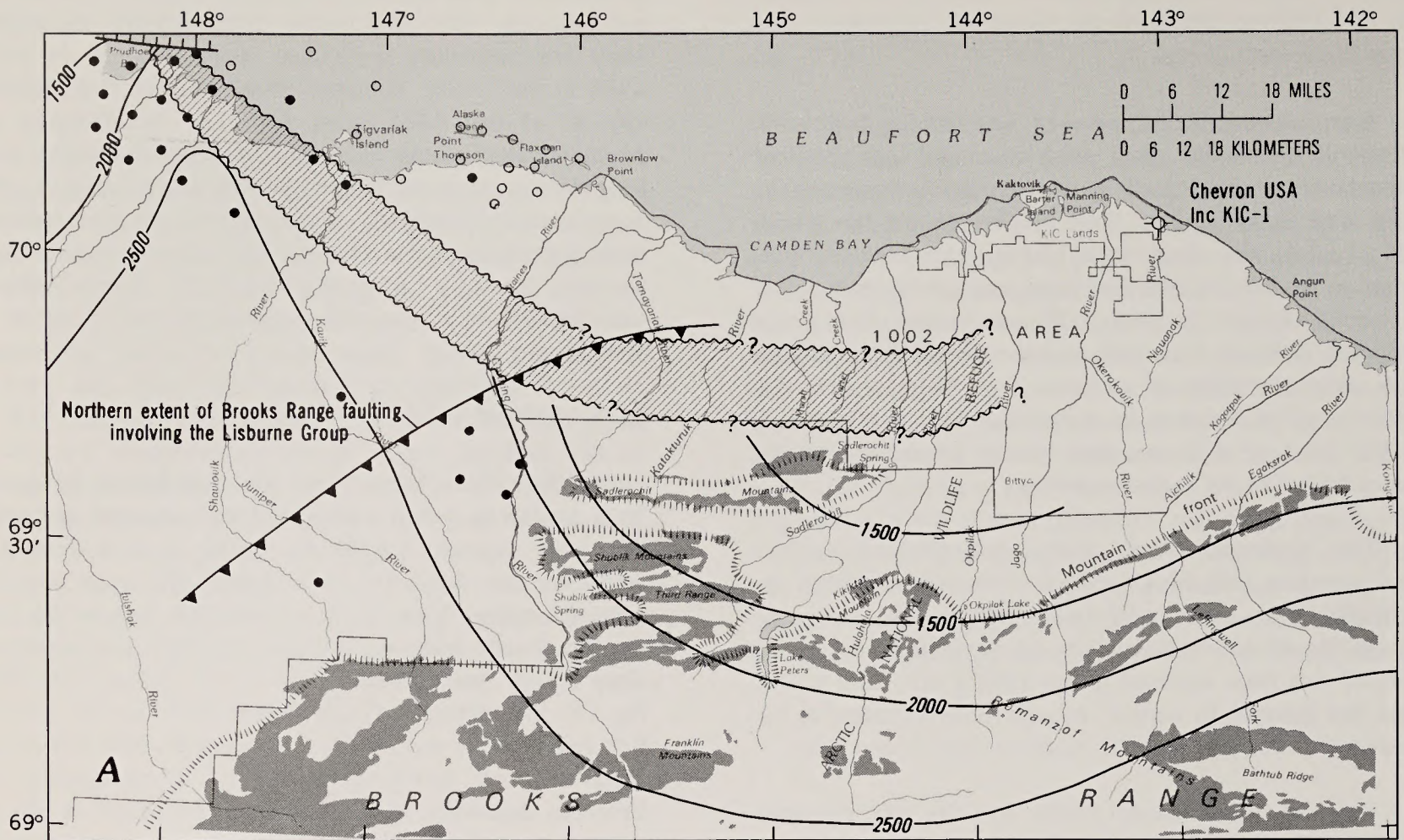
The Brookian sequence consists of thick northeasterly prograding basinal, basin-slope, and marine and nonmarine shelf deposits derived from the ancestral Brooks Range to the south and southwest. These deposits consist dominantly of shale, sandstone, conglomerate, and bentonite (consolidated volcanic ash) that range in age from late Early Cretaceous to Quaternary (fig. III-4), a time span of about 120 million years. In wells immediately west of the 1002 area, the sequence is as much as 13,000 feet thick (fig. III-8; pl. 4), but seismic data indicate that Brookian rocks may be as thick as 26,000 feet in the central part of the 1002 area. However, this thickening could be due in part to duplication caused by thrust faulting.

Potential reservoirs in the Brookian sequence would be primarily lenticular turbidite (deep-water) sandstone beds in the lower part of the Canning Formation. These beds are generally thin, but locally thicker beds are present. They are potentially productive of oil and gas in several wells in the Point Thomson area west of the northwest corner of the 1002 area (pl. 4). Sandstones and conglomerates of the Sagavanirktok Formation also would be good reservoirs for petroleum. However, because of the dominance of sandstone in the section, effective petroleum seals for traps may be limited. Rich oil-prone source rocks occur in the lower half of the Hue Shale. These rocks are considered to be the main potential source for oil in the 1002 area.

DEPOSITIONAL HISTORY

Mountain building of the ancestral Brooks Range may have started in Jurassic time, and the mountain belt was a dominant source of sediment during earliest Cretaceous time. But, as the former land area to the north subsided, initial deposition from the rising mountain belt to the south and southwest was very slow in the 1002 area because a deep trough (the Colville trough of the central North Slope, fig. I-1) that developed immediately north of the mountain belt (which then was much farther south than the present mountain front) had to be filled first. Consequently, initial Brookian deposition in the 1002 area consisted of clay and volcanic ash that settled out of suspension, probably in deep water. These deposits formed the Hue Shale, which is 500 to 1,000 feet thick. Because of poor circulation and low oxygen content of the bottom water during deposition of the lower half of the Hue Shale, pelagic organisms that also settled with the clay were preserved in the sediments to eventually form an organic-rich shale, a good oil source rock.

Deposition became more rapid as delta-front deposits prograded into the area from the southwest. Initially, deep-water mud and sand that slumped or flowed down the basin slope as turbidity currents from the front of shallow-water deltas to the southwest were deposited at the base of the slope. Concurrently, thick deposits of mud were accumulating on the northeastward-prograding basin slope. These deposits formed the Canning Formation, which is 4,000-6,000 feet thick in wells adjacent to the 1002 area (fig. III-8; pl. 4). In much of the 1002 area, however, compressional forces folded and faulted the strata during late Paleocene and early Eocene time, resulting in uplift and erosion of some earlier deposited Brookian sediments and more deposition in adjacent low areas. Deformation and associated deposition continued during middle and late Tertiary time in the eastern part of the 1002 area but the depositional patterns are poorly understood. In the southeastern part of the 1002 area (fig. III-3), a 10,000-foot-thick section of nonmarine sandstone, conglomerate, and shale containing thin beds of coal, which is latest Cretaceous to Paleocene in age and is known as the Jago River Formation, probably was displaced northward by thrust faulting.



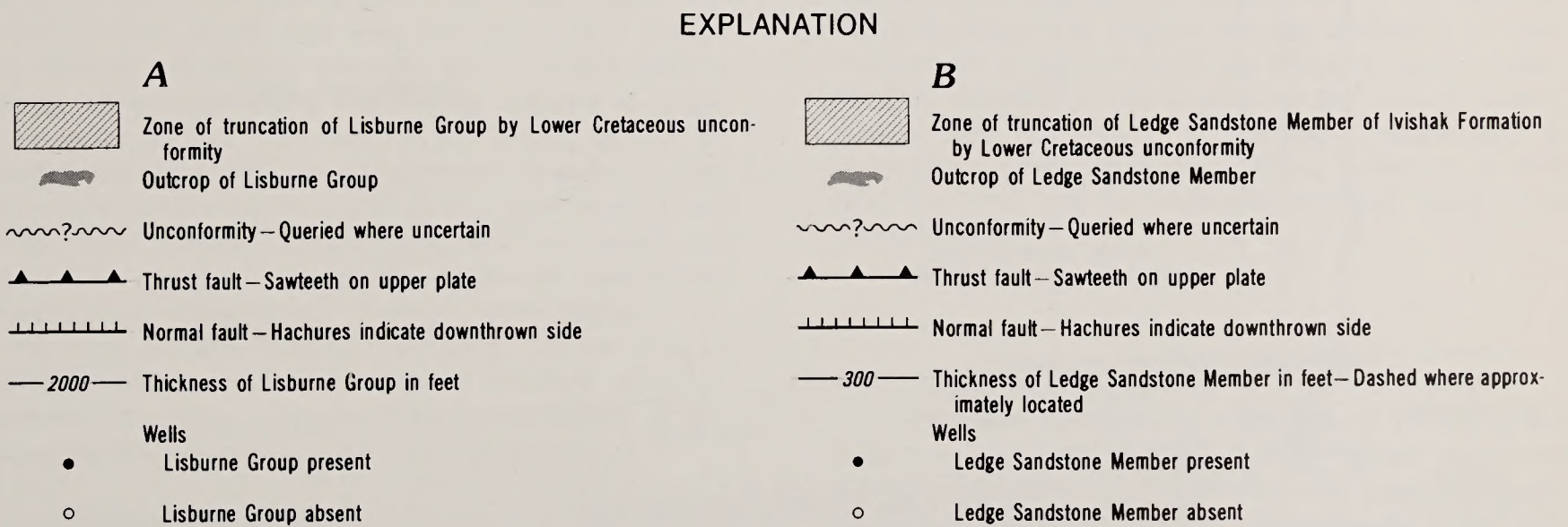
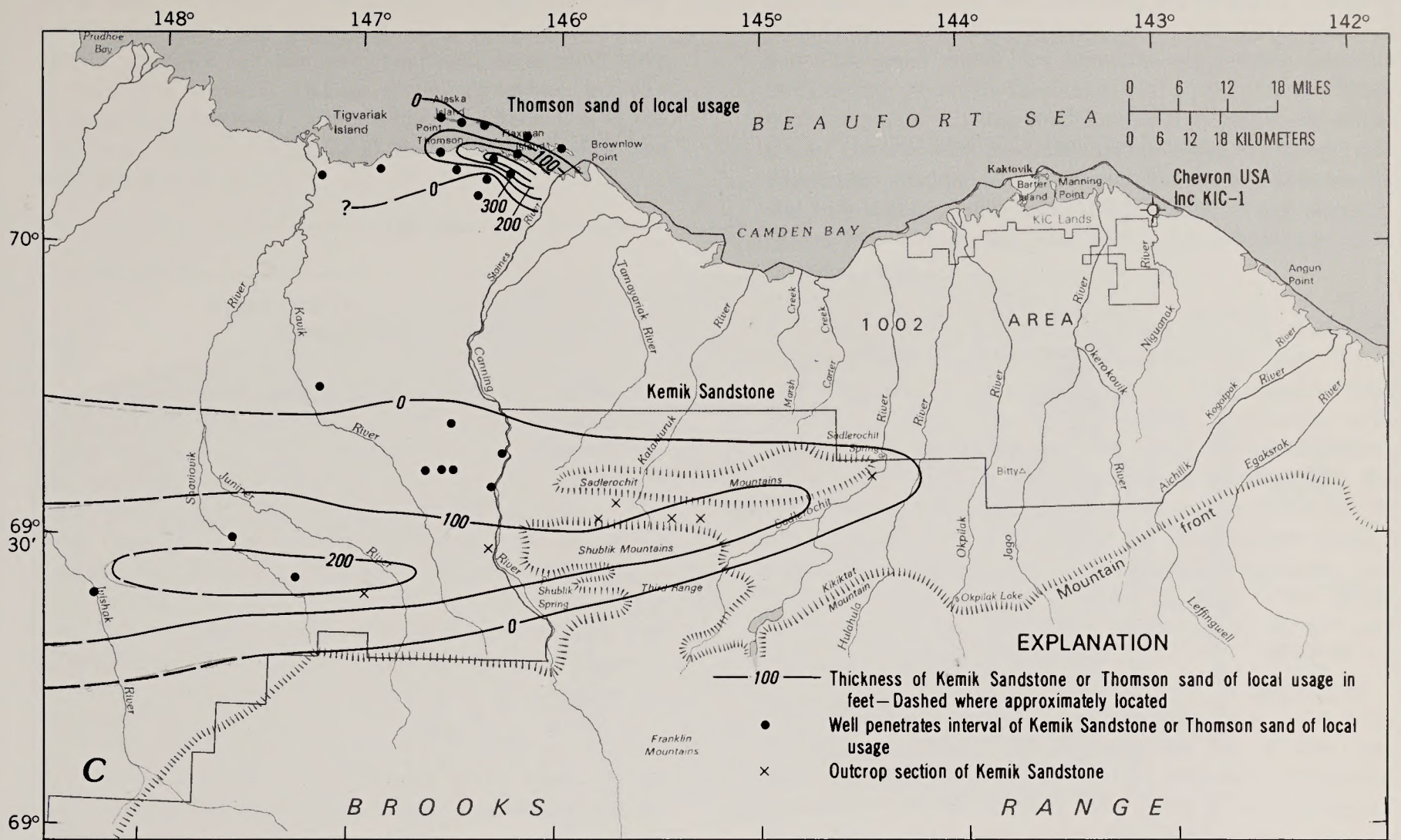


Figure III-7.--Maps (facing and above) summarizing regional and local geologic trends of the Lisburne Group (A), Ledge Sandstone Member of the Ivishak Formation (B), and Kemik Sandstone and Thomson sand (C). (Prepared by the U.S. Geological Survey.)

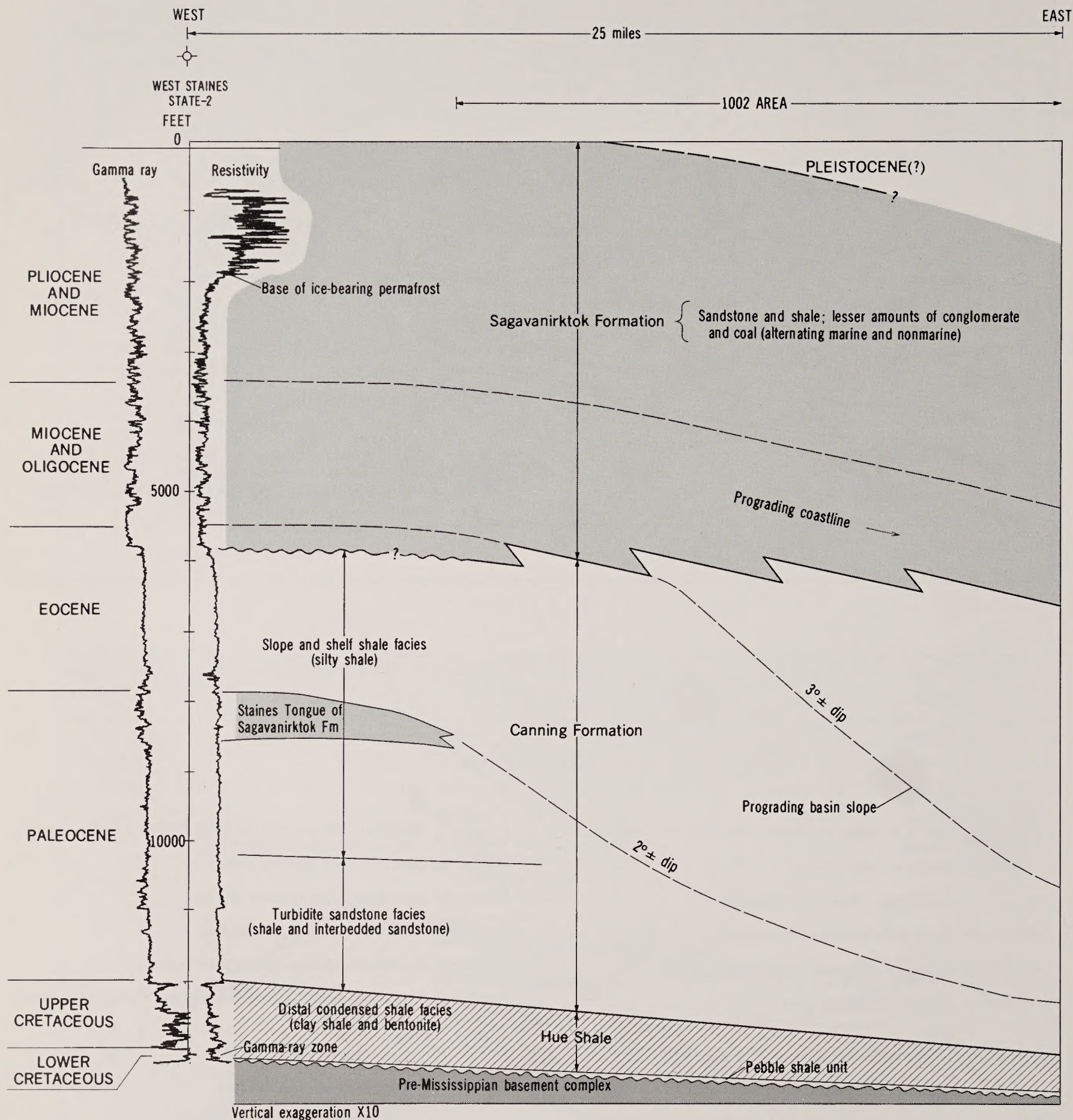


Figure III-8.--Diagrammatic section showing stratigraphic relations of the Brookian sequence between the Mobil West Staines State 2 well and the northwest corner of the 1002 area. Dashed lines represent time lines as inferred from seismic reflections. Depths on well logs are in feet. Ages based on micropaleontologic data. See figure III-3 for location of section. (Prepared by the U.S. Geological Survey.)

Meanwhile, in the northwestern quadrant and areas to the west, after the thick deposits of prodelta or slope muds filled in deeper parts of the seaway, sand, mud, gravel, and peat were deposited along and adjacent to a deltaic shoreline as the sea oscillated back and forth across the area. These deposits make up the Sagavanirktok Formation, the youngest bedrock unit in the 1002 area, which is 5,000-7,000 feet thick in areas to the west (fig. III-8; pl. 4).

Structure

Seismic and surface data indicate that all but the northwestern quadrant of the 1002 area is extensively folded and faulted. This structure is vastly different from the relatively simple structure that underlies the coastal plain west of the Arctic Refuge, such as the Prudhoe Bay area. The line of change in structural style from the simpler structure to the west and the complex structure observed in most of the 1002 area cuts across the northwest part of the 1002 area, approximately coinciding with the north flank of the Marsh Creek anticline (fig. III-3). This dividing line is important in separating the various types of prospects for assessment purposes.

Seismic data, which are of good quality in the northwestern quadrant of the 1002 area, show that the strata are little deformed except for a generally northeast gentle dip. One very low-relief structure, which is an oil and gas prospect, is mapped at the top of the pre-Mississippian surface. The remaining part (southeastern part of the 1002 area) is characterized by complexly folded and faulted structures. Lateral compressional forces have folded and faulted strata into what is called a foreland fold-and-fault belt. The thrust faults move older strata over younger strata; in the 1002 area, the direction and amount of transport has been to the north several miles to tens of miles. The north-verging thrust faults originate at depth, tend to cut through shale layers at low angles, and cut up-section more abruptly in overlying sandstone layers. In the mountains and foothills south of the 1002 area, these detachment surfaces (thrust faults) are in Jurassic and older rock. In the 1002 area, the detachment surfaces are mostly in Cretaceous and younger rocks, although the older rocks are also involved in thrusting. Several large oil and gas fields occur in this type of structural setting in western Wyoming, northern Utah, the foothills of the Canadian Rockies, and in other parts of the world.

The structural patterns produced by this type of deformation are very complex, and because the strata are highly folded and faulted, interpreting the seismic data is difficult. Nevertheless, a seismic reflection from the top of the pre-Mississippian basement, which was mapped over most of the area, shows several very large structural closures (fig. III-1). These closures are discussed with the various prospects or plays later.

Seismic reflections as well as outcrops indicate that Cretaceous and Paleocene rocks are generally much more deformed than either the underlying pre-Kingak or overlying post-Paleocene strata. The reason is that the Cretaceous and Paleocene rocks are mechanically weaker than the underlying pre-Kingak rocks and thus deform more plastically; they are detached from and in places separated by an unconformity from the gently folded overlying post-Paleocene section. Seismic reflections are discontinuous and very difficult, if not impossible, to map for any distance. Figure III-9 shows the near-surface structural trends in Brookian rocks.

The Eocene and younger strata are only moderately deformed in the northeastern part of the 1002 area. There seismic lines show a discontinuity (an unconformity) between the more complexly folded Cretaceous and Paleocene rocks below and the gently deformed Eocene rocks above (pl. 5). This discontinuity indicates that the major deformation probably occurred in late Paleocene to Eocene time, before deposition of the younger Eocene rocks. Deformation continued, probably episodically, into the late Tertiary. Indeed, on the north flank of the Marsh Creek anticline (fig. III-3), tilted Eocene strata dip 60° and overlying Pliocene strata dip 15° .

Twenty-six potential hydrocarbon traps have been seismically mapped at or near the top of the pre-Mississippian surface (fig. III-1). Generally, prospects occurring near this horizon have three or more objective reservoirs. Table III-2 summarizes the pertinent data for each prospect.

No prospects were adequately resolved within the detached and highly deformed Mesozoic and Tertiary rocks. However, figure III-10 shows the distribution of structural culminations in these deformed rocks. Structural analogs in Canada--the Alberta disturbed belt--and in the Montana-Wyoming thrust belt suggest that the probability of traps occurring in the subsurface in this structural setting is high, although determining their location on the basis of existing seismic data is difficult. In addition, a narrow zone of north-dipping strata along the southern margin of the 1002 area (fig. III-10) may be interrupted by faults which could trap petroleum.

Petroleum Geochemistry

Petroleum geochemistry deals with (1) identifying and quantifying petroleum source rocks (which rock units contain sufficient organic matter and how much), (2) determining the type of source rock (oil-prone versus gas-prone), (3) identifying the specific source rock responsible for oil and gas from seeps, outcrops, and wells, (4) determining thermal maturity of the source rock (whether subjected to enough heat to convert organic matter to petroleum), and (5) determining the time of generation of oil and gas and the direction in which it migrated. In the 1002 area (where there is no well control), most of these data

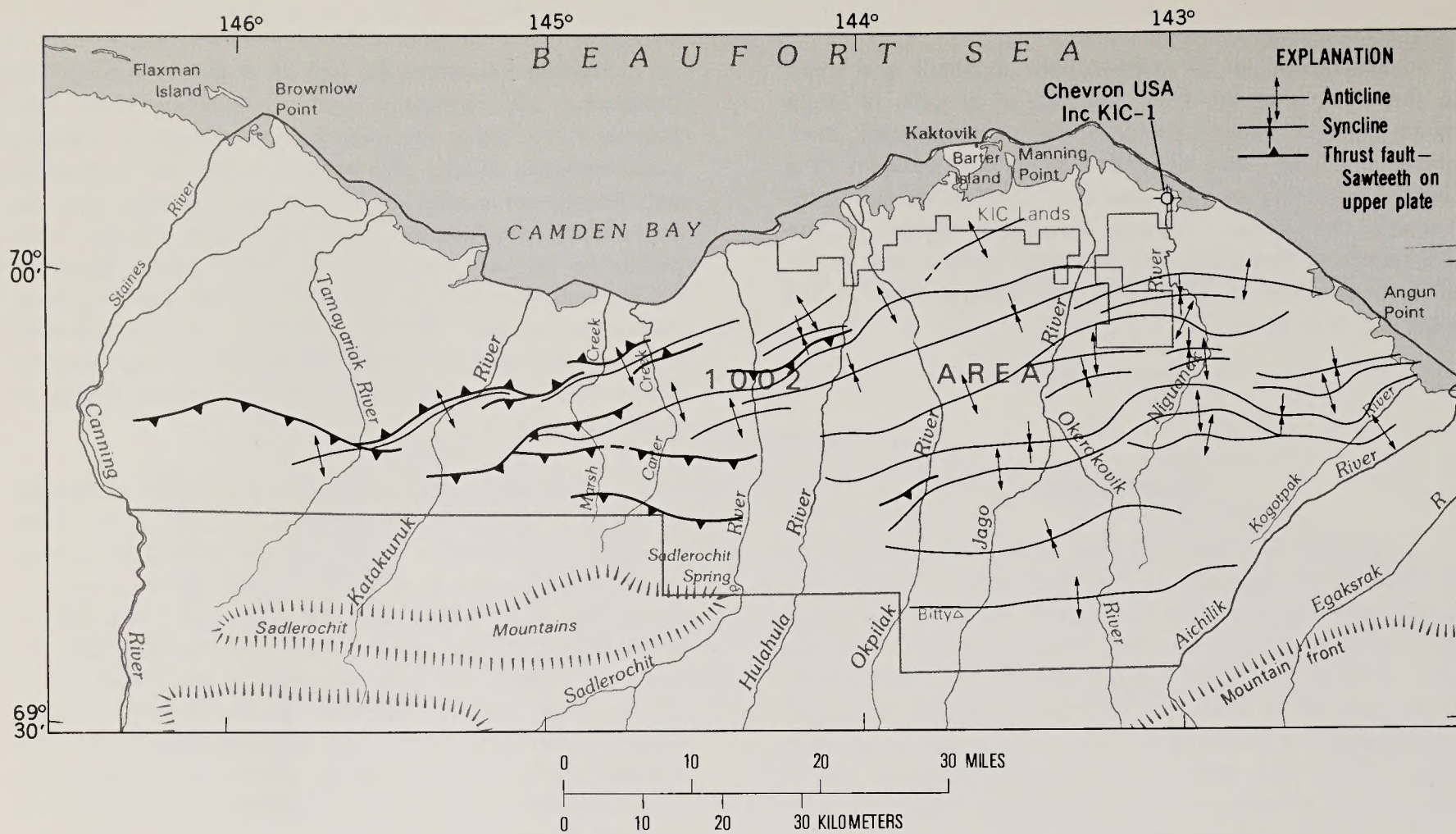


Figure III-9.--Generalized near-surface structural trends in Brookian rocks, based on seismic data. Because of structural complexity, not all features are shown, particularly in the east part of the 1002 area. (Prepared by the U.S. Geological Survey.)

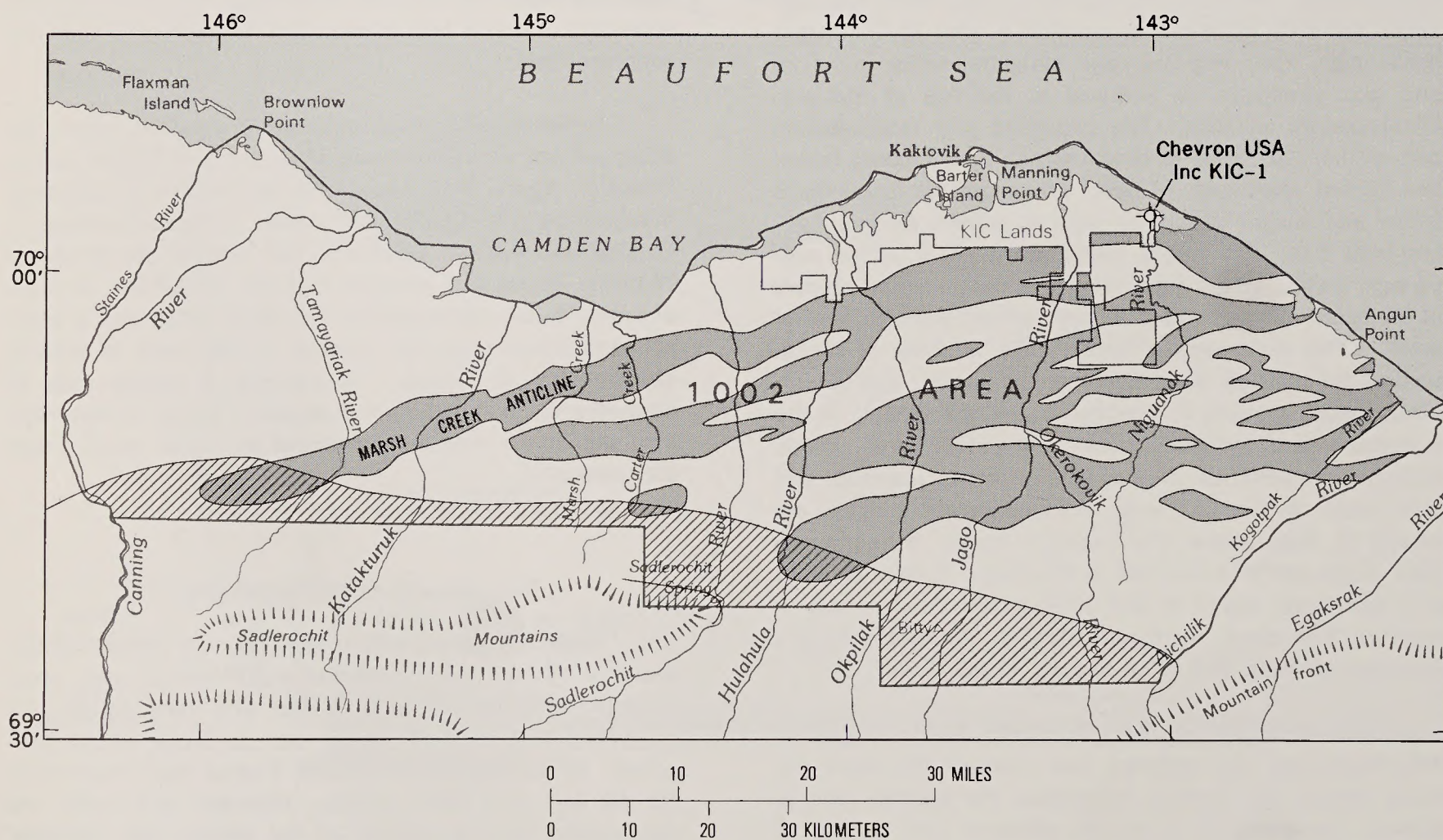


Figure III-10.--Trends of structural culminations in highly deformed Mesozoic and Tertiary rocks (shaded) and area of monoclinally north-dipping strata (line pattern) that may have petroleum potential in the 1002 area. (Prepared by the Bureau of Land Management.)

Table III-2.--Data on seismically mapped petroleum prospects in the 1002 area shown in figure III-1.

[Depths are below mean sea level. Potential objectives: 1, pre-Mississippian carbonate rocks; 2a, Ellesmerian clastic rocks; 2b, Ellesmerian carbonate rocks; 3, Thomson/Kemik sandstones; 4, turbidites; 5, lower Neogene(?) topsets. Data from Bureau of Land Management, 1986.]

Prospect	Area (acres)	Size (miles)	Crestal depth (feet)	Lowest closing contour (feet)	Potential objectives					Number of seismic lines	
					1	2a	2b	3	4		5
1	48,512 ¹	18 X 6	14,000	15,000	X	X	X	X	X	--	5
2	11,793	8 X 3	14,820	15,000	X	X	--	X	X	--	2
3	13,120	12 X 3	13,000	14,200	X	X	X	X	X	--	3
4	12,922	8 X 3.5	14,900	15,500	X	--	--	X	X	--	4
5	34,234	16 X 4	12,700	15,000	X	X	--	X	X	--	6
6	11,940	10 X 3	11,500	13,800	X	--	--	X	X	--	3
7	18,970	16 X 2	8,500	10,500	X	X	X	X	X	--	6
8	4,880	4 X 2	16,300	17,000	X	--	--	X	X	--	2
9	2,200	4 X 1	12,500	13,200	X	--	--	X	X	--	1
10	6,291	11 X 1	11,900	12,500	X	--	--	X	X	--	3
11	9,430 ¹	8 X 3	5,200	6,000	X	X	X	X	--	--	2
12	3,950	6 X 1	19,000	21,000	X	--	--	X	X	--	2
13	1,344	4 X 0.8	10,900	11,500	X	X	X	X	--	--	1
14	4,915 ¹	5 X 2	5,640	6,000	X	X	X	X	--	--	1
15	42,500 ¹	13 X 10	22,500	23,000	X	--	--	X	X	--	6
16	6,720	6.3 X 2.4	1,230	2,300	--	--	--	--	X	X	3
17	3,170	3 X 2	21,600	22,000	X	--	--	X	X	--	1
18	226,822 ¹	27 X 15	13,500	>24,000	X	--	--	X	X	--	16
19	129,587	22 X 13	9,790	17,000	X	X	X	X	X	--	10
20	79,738	30 X 7	11,900	17,500	X	X	X	--	--	--	10
21	65,300 ¹	21 X 4	7,500	14,500	X	X	X	--	--	--	7
22	4,560 ¹	5 X 2	11,600	12,000	X	X	X	--	--	--	1
23	3,706	5 X 1.5	16,300	16,500	X	X	X	--	--	--	1
24	11,872 ¹	8 X 3	10,400	12,000	X	X	X	--	--	--	4
25	2,360 ¹	4 X 1	11,950	12,000	X	X	X	--	--	--	1
26	4,954	5 X 3	16,500	17,000	X	X	X	X	X	--	2

¹Prospect area includes extensions or projections outside the 1002 area as shown in figure III-1.

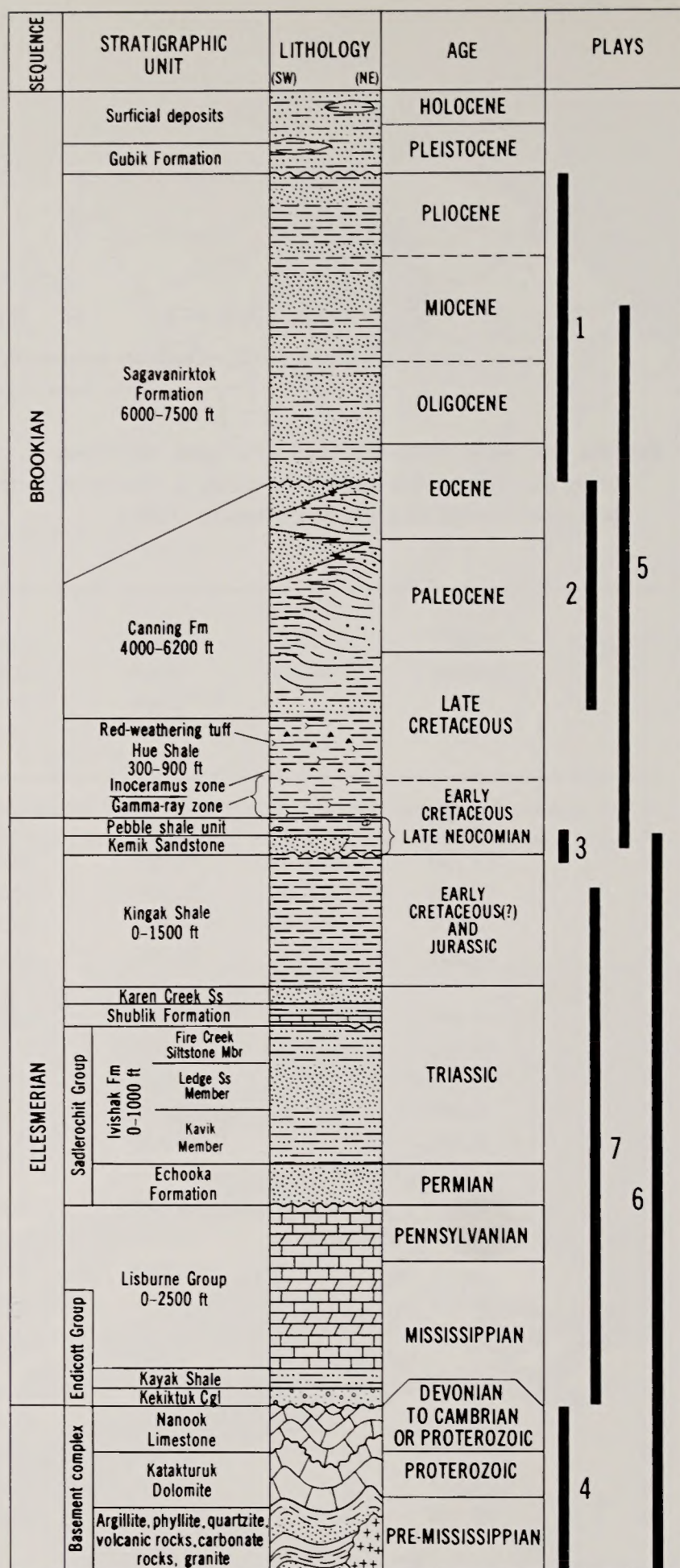
come from surface samples and seismic shot-hole samples or the data must be projected from wells or outcrops in adjacent areas. Because of the different and complex structural history of most of the 1002 area compared with that of adjacent areas to the west, some of the projections are tenuous.

Analyses of different rock units throughout northeastern Alaska indicate that the Shublik Formation, Kingak Shale, pebble shale unit, Hue Shale, and shales in the Canning Formation may be potential oil or gas source rocks (fig. III-4). The first three units are considered to be the source for the oil in the Prudhoe Bay field. However, analytical data on a limited number of samples of some units in or adjacent to the 1002 area indicate that all the above units except the Hue Shale are gas-prone source rocks of fair to good quality and that the Hue Shale is a good to excellent oil-prone source rock. In addition, the distribution of the Shublik and Kingak is not known and, because of pre-pebble shale erosion, these rocks may not be present in much of the 1002 area.

Analyses of oils collected from seeps and stained outcrops in or adjacent to the 1002 area, and of the different potential source rocks, suggest that the Hue Shale is the most likely oil source rock in the 1002 area. None of the sampled oils are similar to Prudhoe Bay oil.

Maturation studies indicate that, in the outcrop belt south of the 1002 area, all potential source rocks are mature to overmature, the latter having been overheated by deep burial and so petroleum had already been generated and expelled. In wells in the Point Thomson area, where the rocks are now at or near their maximum burial depths, the Hue Shale and pebble shale unit are at the beginning of hydrocarbon generation. According to maturation data and downward-extrapolated temperature gradients from these wells, the maturity thresholds of oil, condensate, and thermal gas are about 12,000, 22,500, and 28,000 feet depth, respectively. These threshold values can be extrapolated into the northwestern quadrant of the 1002 area with a fair degree of confidence, but in the structurally complex area to the east there are complications. Where the Hue Shale is at or near the surface, it is immature, but seismic data indicate that it could be as deep as 25,000 feet in nearby areas. Thus, depending on its structural position, the Hue Shale ranges from immature to mature or overmature.

In the deformed eastern part of the 1002 area, data are insufficient to determine the time of oil generation with respect to the formation of petroleum traps. It seems likely, however, the generation occurred before, during, and after formation of the traps because the Hue Shale, the main source rock, occurs in such a wide range of burial depths and maturation stages. The time range of oil generation was probably long enough for reservoirs in early-formed as well as late-formed traps to be charged by migrating petroleum.



EXPLANATION

	Conglomerate		Limestone		Bentonite
	Sandstone		Dolomite		Siliceous
	Siltstone		Granite		Concretion
	Shale				Inoceramus

ASSESSMENT OF THE OIL AND GAS POTENTIAL

In-Place Oil and Gas Resources

The method employed for estimating in-place oil and gas resources for the 1002 area is a modified version of the play analysis technique developed by the Geological Survey of Canada to assess Canada's oil and gas resources (Canada Department of Energy, Mines and Resources, 1977) and used in earlier assessments of the National Petroleum Reserve in Alaska (NPRA) and the 1002 area (U.S. Department of the Interior Office of Minerals Policy and Research Analysis, 1979; Mast and others, 1980; Miller, 1981; Bird, 1986). But the present assessment uses a more efficient computer program (Fast Appraisal System for Petroleum--FASP), utilizing probability theory rather than Monte Carlo simulation (Crovelli, 1985, 1986).

In this method, geologic settings of oil and gas occurrence are modeled, risks are assigned to geologic attributes of the model necessary for generation and accumulation of petroleum, and ranges of values are assessed for the geologic characteristics of traps and reservoirs which control petroleum volumes within the modeled accumulations of each play. The volumes of petroleum in the hypothetical traps are determined using reservoir engineering formulas, and summed for the play as a whole. Consequently, a play can be viewed as an aggregate of prospects which are conceived as having similar geologic characteristics and sharing common geologic elements. They are defined by a known or suspected trapping condition, which may be structural, stratigraphic, or combination in character.

In this appraisal method, geologists make judgments about the geologic factors necessary for formation of an oil or gas deposit and quantitatively assess those geologic properties which determine its size. The computer program (FASP) then does the resource calculation based on that information. This arrangement utilizes the geologist's expertise with geologic factors and the computer's facility in manipulation of numbers. The method provides for a systematic analysis and integration of the geologic factors essential for the occurrence of oil and gas, a thorough documentation of the analysis, and an assessment which provides information on the size, distribution, and number of petroleum accumulations as well as their sum.

In this assessment, seven plays were identified, encompassing Precambrian to Cenozoic rocks (fig. III-11), and in-place oil and gas resources were estimated for each play. Estimates for each of the seven plays were aggregated using probability theory to produce estimates for the 1002 area.

Figure III-11.--Generalized stratigraphic column (facing page) for the 1002 area showing intervals of assessed plays. (Prepared by the U.S. Geological Survey and the Bureau of Land Management.)

DESCRIPTION OF PLAYS

Brief descriptions of the seven plays follow, including a cross section showing geologic relations and maps showing the play limits (fig. III-12). Some plays are similar or equivalent to oil and gas plays having known petroleum in adjoining areas. The plays are presented in the order that they were assessed rather than according to their estimated oil and gas potential.

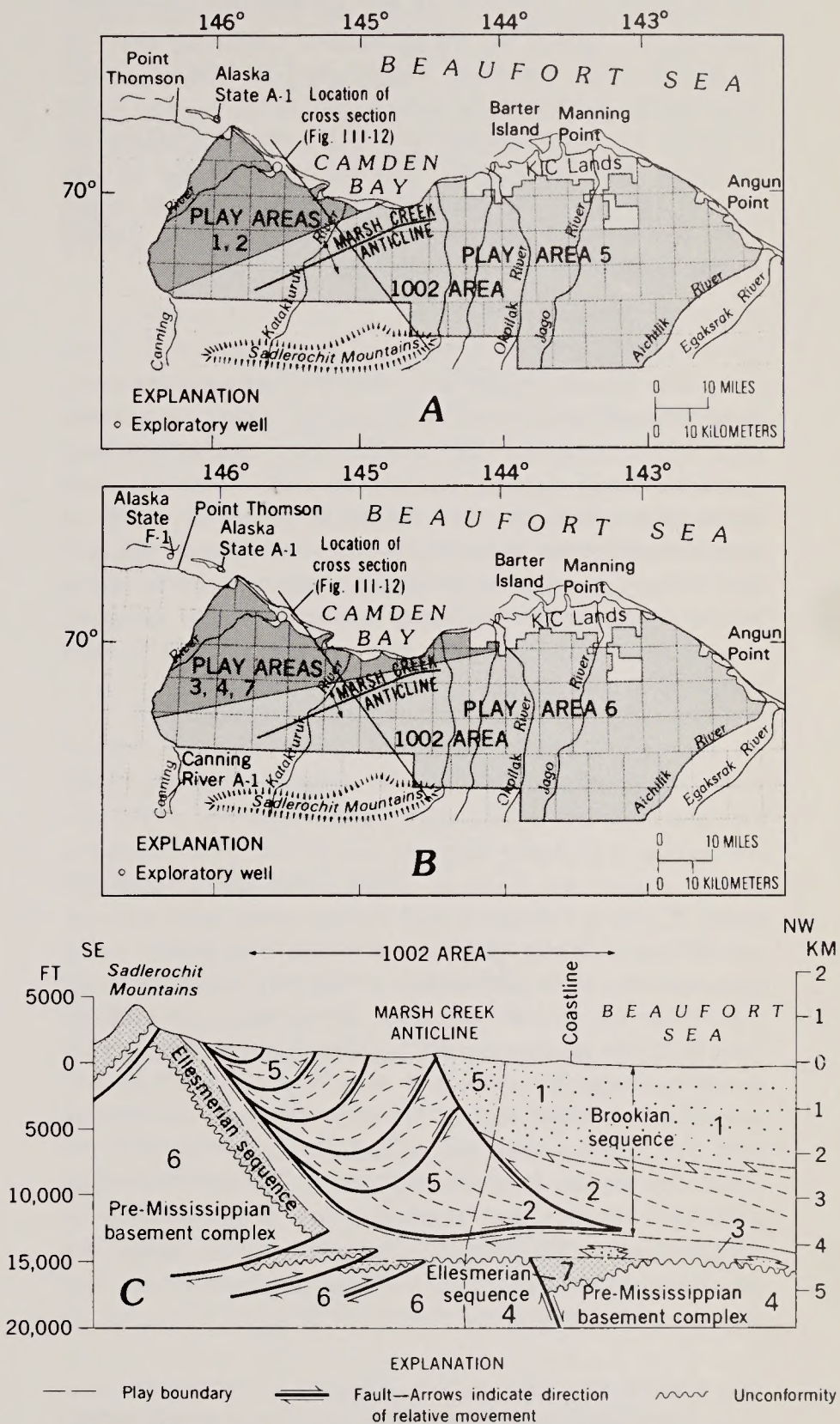


Figure III-12.--Maps and schematic section showing the seven assessed plays in the 1002 area: 1, Topset; 2, Turbidite; 3, Thomson-Kemik; 4, Undeformed Pre-Mississippian; 5, Imbricate Fold Belt; 6, Folded Ellesmerian/Pre-Mississippian; and 7, Undeformed Ellesmerian. (Prepared by the U.S. Geological Survey and the Bureau of Land Management.)

TOPSET PLAY

The Topset play consists of stratigraphic traps in sandstone reservoirs of Tertiary age and includes those rocks represented on the seismic records in the topset position in a topset-foreset-bottomset sequence. This play is limited to the northwestern part of the 1002 area and is generally unaffected by Brooks Range folding and faulting (fig. III-12A, C). The southeastern boundary is the line marking the north flank of the Marsh Creek anticline. These rocks, on the basis of well penetrations immediately west of the 1002 area, are assigned to the Sagavanirktok Formation and consist of marine and nonmarine deltaic sandstone, siltstone, shale, conglomerate, and minor amounts of coal. A maximum thickness of 10,000 feet, estimated from the seismic records, occurs in the eastern part of the play; the sequence thins westward to about 7,000 feet in wells just west of the Arctic Refuge. Drilling depths range from 100 to 10,000 feet.

The reservoir rocks are composed of sandstone and conglomerate which may constitute as much as half the total thickness of the play interval, even though individual reservoir beds seldom exceed 50 feet. Fair to good reservoir continuity in sand bodies is expected parallel to depositional strike (northwestward), but marked changes may occur over short distances perpendicular to strike. Porosity of reservoir rocks is expected to be excellent, averaging 10-32 percent, and permeability is in the hundreds of millidarcies.

Potential source rocks immediately associated with the reservoirs are deltaic shales and mudstones which are immature and probably biogenic gas prone. The underlying marine shales are both oil prone (Hue Shale) and gas prone (Canning Formation and pebble shale unit), and are mature below about 12,000 feet in the play area. As a consequence, oil accumulations in this play are likely to be the result of vertical migration along faults or inclined foreset beds in the underlying Canning Formation. Oil shows are reported in several wells in the Point Thomson area from the lower part of the rock sequence included in this play. The multi-billion-barrel heavy oil and tar accumulations just west of the Prudhoe Bay field (West Sak and Ugnu fields) and the small oil accumulations in northeastern NPRA (Simpson and Fish Creek fields) are considered to be analogs for potential accumulations in this play.

Postulated traps in this play are mostly stratigraphic, related to facies changes, or combination structural and stratigraphic traps formed against small-displacement normal faults. Faults, interbedded shales, facies changes, permafrost, and asphaltic petroleum are expected to provide only fair to poor seals. Poor seals--that is, barriers to petroleum migration--may have allowed preferential escape of gas, leaving mostly oil accumulations in this play.

TURBIDITE PLAY

The Turbidite play consists of stratigraphic traps in deep-marine sandstone reservoirs of Late Cretaceous and Tertiary age which occur in the foreset and bottomset units of the Canning Formation as shown by seismic reflectors. The play is limited to the northwestern part of the 1002 area that is generally unaffected by Brooks Range folding and faulting (fig. III-12A, C). The southeastern play boundary is a line marking the boundary between folded and faulted rocks of the Marsh Creek anticline and the adjacent undeformed rocks. On the basis of well penetrations adjacent to the 1002 area, these rocks consist of relatively deep-marine shale, siltstone, and turbidite sandstone. Maximum thickness for rocks in this play is about 5,000 feet. Drilling depths range from 4,000 to 22,000 feet.

Reservoir rocks, which are turbidite sandstones, may occur anywhere within the play interval, but in wells adjacent to the 1002 area they occur mostly in the lower third as toe-of-slope or basin-plain turbidites. Sandstone bodies are expected to be laterally discontinuous and to have an aggregate thickness of several hundred feet, although individual beds are expected to be less than 50 feet thick. Abnormally high fluid pressures are expected in the lower part of the play interval as in wells west of the Arctic Refuge, and so porosities should be better than normally encountered for turbidite sandstones at these depths.

Potential source rocks include deep-marine shale adjacent to the reservoirs (the Canning Formation) and below the reservoirs (the Hue Shale and pebble shale unit). These shales are gas prone (Canning Formation and pebble shale unit) and oil prone (Hue Shale) and are mature below about 12,000 feet. Oil and gas have been recovered from turbidite reservoirs in several wells adjacent to the Arctic Refuge. The oil, generally 21° to 27°API gravity, but as high as 44° in one occurrence, has been recovered on drillstem tests at rates of as much as 2,500 barrels per day. Gas flows of 2.25 million cubic feet per day were also measured in the Alaska State A-1 well adjacent to the northwest corner of the 1002 area.

Postulated traps in this play are mostly stratigraphic and are related to facies changes or traps formed against small-displacement normal faults; three broad, low-amplitude structures have been identified seismically. Faults and the surrounding thick marine shales are expected to provide fair to good seals.

THOMSON-KEMIK PLAY

The Thomson-Kemik play consists of stratigraphic traps in sandstone reservoirs of Early Cretaceous (Neocomian) age in the Kemik Sandstone or the equivalent Thomson sand. This play is limited to the northwestern part of the 1002 area that is generally unaffected by Brooks Range folding and faulting (fig. III-12 B, C). The

southeastern play boundary is a line marking the boundary between folded and faulted rocks of the Marsh Creek anticline and the adjacent undeformed rocks. Sandstone in this play overlies the Lower Cretaceous regional unconformity, was deposited under shallow marine to possibly nonmarine conditions, and is expected to be discontinuous. Drilling depths range from 12,000 to 25,000 feet.

The reservoir rock may range from fine-grained, well-sorted quartzose sandstone (Kemik) to detrital dolomite and quartz conglomeratic sandstone (Thomson). Thicknesses of as much as 345 feet have been penetrated by wells, but the distribution of sandstone is unpredictable and appears to be seismically undetectable. Average porosity is expected to be about 12 percent. Abnormally high fluid pressures are expected in this play as in wells west of the Arctic Refuge in these same units. Owing to abnormal pressures, porosities are expected to be better than normal for similar sandstone at these depths.

Potential source rocks include the overlying Canning Formation, Hue Shale, and pebble shale unit and, possibly, the Kingak Shale and Shublik Formation where these formations are present beneath the regional unconformity. Geochemical data indicate that the Hue Shale is oil prone and the other units are gas prone and, in the play area, may be marginally mature to mature. Both oil and gas are present in the Thomson sand in the Point Thomson field, which is reported by the Exxon Corporation to contain reserves of 5 trillion cubic feet of gas and 375 million barrels of condensate. Flow rates are reported to be as much as 13 million cubic feet of gas and 2,283 barrels of oil per day. Oil gravity generally ranges from 35° to 45°API, but some oil as low as 18°API has been reported.

Postulated traps in this play are mostly stratigraphic and are related to facies changes or traps formed against small-displacement normal faults; three broad, low-amplitude structures have also been identified seismically. Faults and the overlying thick marine shales are expected to provide fair to good seals.

UNDEFORMED PRE-MISSISSIPPIAN PLAY

The Undeformed Pre-Mississippian play consists of stratigraphic traps in carbonate or sandstone reservoirs in the pre-Mississippian basement complex. In this play, it is critical that the reservoir rocks be charged and sealed by source rocks in the overlying Ellesmerian or Brookian sequences. Pre-Mississippian rocks were metamorphosed, folded, faulted, uplifted, and eroded prior to deposition of younger rocks. The occurrence of reservoir rocks in the basement complex is unpredictable. This play is limited to the northwestern part of the 1002 area that is unaffected by Brooks Range folding and faulting (fig. III-12B, C). The southeastern play boundary is a line marking the boundary between folded and faulted rocks just north of the Marsh Creek anticline and the adjacent undeformed basement rocks. Drilling depths are expected to be 12,000 to 25,000 feet.

Potential reservoir rocks may be dolomite, limestone, and sandstone. Dolomites may be vuggy as observed in outcropping Katakturuk Dolomite. Sandstone may also be present. Under favorable conditions, leaching of calcareous cements may have improved the reservoir character. Although carbonate rocks may locally have porosity of as much as 25 percent, the average porosity is expected to be less than 10 percent. Fractures are expected in these rocks and should enhance the observed low permeabilities of the matrices. Flow rates from basement rocks in the Alaska State F-1 well were about 3 million cubic feet of gas and 150 barrels of 35°API gravity oil per day. Salt water was recovered from the Alaska State A-1 well at a rate of 6,800 barrels per day and fresh water was recovered from the Katakturuk Dolomite in the Canning River A-1 well at a rate of 4,800 barrels per day. Abnormally high formation pressures are present in the basement rocks in some Point Thomson wells.

Source rocks within the pre-Mississippian basement are unlikely because of the regional metamorphic character of these rocks. Hence, juxtaposition of younger (Cretaceous or Tertiary) source rocks with basement reservoir rocks is critical for petroleum accumulations in this play. The Hue Shale is expected to be a mature oil-prone source rock, and the Canning Formation and pebble shale unit, gas-prone source rocks. Possible asphaltic petroleum is described from the Katakturuk Dolomite in the Canning River A-1 well, and oil and gas have been recovered from Point Thomson wells.

Postulated traps in this play are stratigraphic and are located in areas where truncation placed Cretaceous or Tertiary source rocks in contact with reservoirs in the basement.

IMBRICATE FOLD BELT PLAY

The Imbricate Fold Belt play consists chiefly of structural traps in sandstone reservoirs of Cretaceous and Tertiary age. Structural traps are the result of Brooks Range folding and faulting. This play encompasses that part of the area southeast of a line marking the limit of deformation of rocks along the north flank of the Marsh Creek anticline (fig. III-12A, C). Rocks included in this play are bounded below by a major structural detachment zone, which in the area of the Sadlerochit Mountains lies within the Kingak Shale, and in the subsurface to the north is believed to cut stratigraphically up-section and eventually to die out within rocks of the Marsh Creek anticline.

Sandstone reservoirs in this play may include the Kemik Sandstone, Canning Formation turbidites, and Sagavanirktok Formation deltaic deposits. Drilling depths in this play range from 100 to about 26,000 feet. The turbidite reservoirs are expected to be most prospective in this play. Distribution of the Kemik is expected to be unpredictable as in the Thomson-Kemik play. Deltaic sandstones are generally expected to have the same excellent reservoir but poor sealing characteristics as described in the Topset

play; also included are the very poor reservoir sandstones and conglomerates that crop out along Igilatvik (Sabbath) Creek east of the Jago River in the southeastern part of the area (fig. III-3). The distribution of this thick section of rocks (Jago River Formation) beyond the area of surface exposure is unknown.

Potential source rocks include the Kingak Shale, pebble shale unit, Hue Shale, and Canning Formation. These shales may be present within this play or below the detachment zone in the subjacent Folded Ellesmerian/Pre-Mississippian play. The Canning Formation is expected to be a poor, submature source rock, whereas Cretaceous and Jurassic shales are expected to be fair to good source rocks in the submature to mature range. Oil seeps at Manning Point and Angun Point are thought to be from rocks assigned to this play. In addition, oil-stained sandstone is known from many outcrops of these rocks.

Traps in this play are mainly structural and are expected to consist of relatively small but numerous fault-cored anticlines. Stratigraphic traps, such as updip pinchouts on the flanks of anticlines, may also be present. Shales within the play are expected to provide fair to good seals for these traps, although faulting and related fracturing may reduce their effectiveness.

FOLDED ELLESMERIAN/PRE-MISSISSIPPIAN PLAY

The Folded Ellesmerian/Pre-Mississippian play consists mostly of structural traps in sandstone or carbonate reservoirs of earliest Cretaceous to pre-Mississippian age. The structures are the result of Brooks Range folding and faulting. This play underlies nearly the same area as the Imbricate Fold Belt play. The play area lies southeast of a line marking the approximate northern limit of deep basement faulting which lies just north of the surface trace of the Marsh Creek anticline (fig. III-12, B, C). Rocks in this play lie beneath the major structural detachment zone which marks the base of the overlying Imbricate Fold Belt play, and reservoirs consist mainly of Ellesmerian and pre-Ellesmerian rocks. Depending on the stratigraphic level of the main structural detachment zone, some Brookian rocks may also be included.

Reservoirs in this play consist of both carbonate rocks and sandstone. Potential carbonate reservoirs include the Katakturuk Dolomite, Nanook Limestone, other unnamed pre-Mississippian carbonate rocks, Lisburne Group, and Shublik Formation. Potential sandstone reservoirs include pre-Mississippian sandstone, Kekiktuk Conglomerate, Echooka Formation, Ivishak Formation, Karen Creek Sandstone, Kemik Sandstone, and possibly turbidite sandstones in the basal part of the Brookian sequence. The most important sandstone reservoir is expected to be the Ivishak Formation (Ledge Sandstone Member) and the most important carbonate reservoirs, the Lisburne Group and Katakturuk Dolomite. The areal distribution of reservoirs in this play is uncertain. The uncertainty is caused by the Lower Cretaceous regional unconformity in

which erosion has removed an undetermined amount of underlying strata. The Ivishak Formation and Lisburne Group can be projected eastward from the Sadlerochit Mountains into the subsurface of the southernmost part of the 1002 area with a relatively high degree of confidence. North of this area, the character of seismic reflections offers the possibility of their presence. However, their northern extent depends on several factors, such as the rate of truncation on the unconformity, the amount of northward transport by thrust faulting, and the possible existence of downdropped fault blocks north of the truncation edge, about which we have little direct information. Drilling depths range from 2,000 to 25,000 feet.

Potential source rocks include marine shales in the Kayak Shale, Ivishak Formation, Shublik Formation, Kingak Shale, pebble shale unit, and possibly the Hue Shale. The Hue Shale is expected to be the best oil-prone source rock where it occurs at depths shallower than the thermal gas threshold (about 22,000 feet). The other shales are all apparently gas-prone source rocks. They are generally mature to possibly overmature. As with reservoir rock described above, truncation is expected to reduce the areal extent of all pre-pebble shale unit source rocks by an unknown amount.

Traps in this play are mostly structural and are expected to consist of a relatively few large, broad anticlines and fault traps. A significant number of structures smaller than the present 3- by 6-mile seismic grid is also expected to be present. Stratigraphic traps related to truncation by the Early Cretaceous unconformity are also possible. The pebble shale unit and younger shales are expected to provide good to excellent seals.

Within this play area, two extremely large structures were seismically identified (prospects 18 and 19 shown on figure III-1 and table III-2). These two structures were each assessed independently from the other structures composing this play, and special consideration was given to their position relative to the Ellesmerian truncation edge and the relation of trap fill to petroleum-column height.

UNDEFORMED ELLESMERIAN PLAY

The Undeformed Ellesmerian play consists of stratigraphic traps in carbonate or sandstone reservoirs in the Ellesmerian sequence. The play is limited to the northwestern part of the area that is unaffected by Brooks Range folding and faulting (fig. III-12B, C). The southeastern play boundary is a line marking the boundary between folded and faulted rocks and adjacent undeformed Ellesmerian rocks. This boundary coincides with the northwest boundary of the Folded Ellesmerian/Pre-Mississippian play. A wedge of Ellesmerian rocks is seismically mapped beneath the Lower Cretaceous unconformity only in the southwesternmost corner of the play area. Elsewhere in the play area, there may be one or more fault-bounded, downdropped blocks which preserve Ellesmerian rocks. Such fault-bounded blocks are well

known in the Prudhoe Bay area but have not been identified thus far on the seismic data in the 1002 area. Drilling depths to Ellesmerian rocks are 12,000 to 25,000 feet.

Potential reservoirs consist of both sandstone and carbonate rocks. The most important reservoirs are expected to be dolomite in the Lisburne Group and sandstone in the Ledge Sandstone Member of the Ivishak Formation. Reservoir properties may be improved by proximity to the unconformity, as at Prudhoe Bay. Average carbonate porosity is expected to be about 4 percent and average sandstone porosity, about 15 percent.

Potential source rocks include marine shales within the Kayak Shale, Ivishak Formation, Shublik Formation, Kingak Shale, and the overlying pebble shale unit and Hue Shale. These shales are expected to be submature to mature. Only the Hue Shale is expected to be an oil-prone source rock.

Postulated traps in this play are stratigraphic and depend for seals on the pebble shale unit or younger shales.

ESTIMATES AS DISTRIBUTIONS

The estimates of in-place oil and gas resources included in this report are in the form of complementary cumulative probability distributions, as shown in figure III-13. These distributions summarize the range of estimates generated by the FASP computer program as a single probability curve in a "greater than" mode. Because of the uncertainty attached to the many geologic variables, no single answer is possible to the question of how much oil and gas are present; instead, an infinite number of answers are possible, each with its own confidence level. There is a 100-percent probability of occurrence of some oil and gas somewhere in the 1002 area. In nature, only one real value exists and the curve is an expression of the uncertainty about its size. The degree of uncertainty is expressed in the "spread" or variance of the distribution. The curve for in-place oil is read as: there is a 50-percent chance that the resource is greater than 11.9 billion barrels, and there is a 5-percent probability that the resource is greater than 29.4 billion barrels. Large quantities correspond to lower probabilities--that is, there is less confidence that those quantities are present. Our estimates are reported at the mean and at the 95th and 5th probability levels, considered by us to be "reasonable" minimum and maximum values.

ESTIMATED IN-PLACE RESOURCES

In-place oil and gas resources contained within the 1002 area are estimated to range from 4.8 billion to 29.4 BBO and from 11.5 to 64.5 TCFG, at the 0.95 and 0.05 probability levels, respectively (fig. III-13). Though indicating a relatively high degree of uncertainty regarding the true value, this wide range of values does indicate the potential for unusually large resources, or the possibility that there

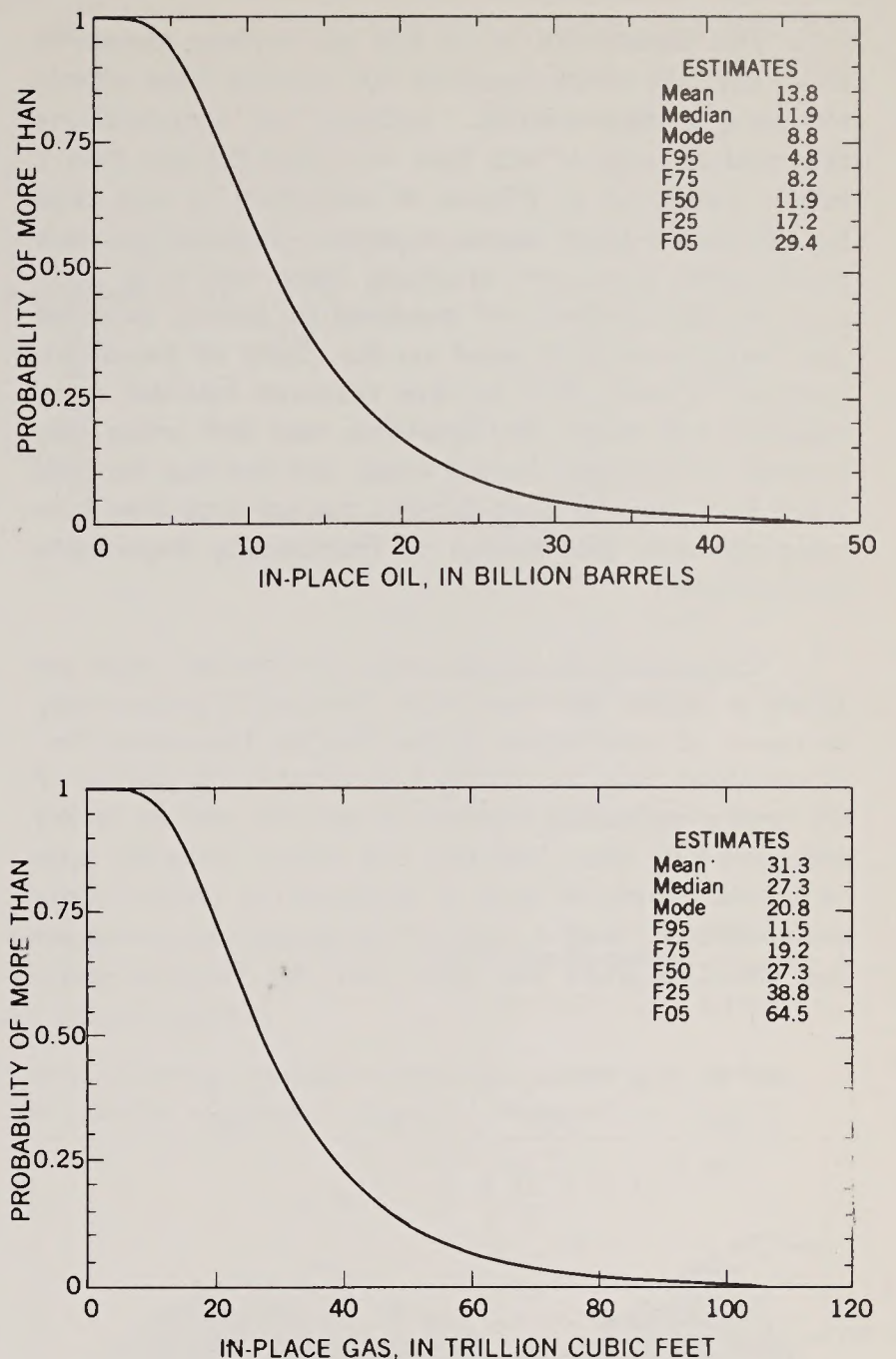


Figure III-13.---Probability curves showing the estimated in-place oil and total gas resources of the 1002 area. Oil in billions of barrels; gas in trillions of cubic feet. F, fractile. (Prepared by the U.S. Geological Survey.)

may be no exploitable petroleum resources in the 1002 area. For perspective, the Prudhoe Bay field is calculated to have initially contained about 23 BBO in-place and more than 35 TCFG in-place in Triassic reservoirs. Furthermore, an area similar in size and shape to the 1002 area, centered at Prudhoe Bay, encompasses 10 oil and gas accumulations, both economic and subeconomic, containing nearly 60 BBO and 45 TCFG in-place. Mean estimates for the 1002 area are calculated to be 13.8 BBO in-place and 31.3 TCFG in-place; these mean values have probabilities of 40 percent or less of being exceeded.

To facilitate weighing of land-use values within the 1002 area, the mean values of in-place oil and gas resources were assessed for four separate geographic blocks as shown in figure III-14.

This assessment of oil and gas in-place represents those deposits which constitute the resource base without reference to recoverability. Included are accumulations estimated to range in size from very small (far less than 1 million barrels of oil in-place or equivalent) to very large (greater than 1 billion barrels in-place). Included are both stratigraphic traps and structural traps, not only traps unequivocally identified and measured by seismic data, but also traps inferred to exist on the basis of framework geology. Clearly, this in-place resource includes many deposits well below any economic size limit which may currently be assumed for the Arctic, and includes deposits which have reservoir characteristics that preclude them from being economic (see section on Economically Recoverable Oil Resources).

Estimated in-place resources of individual plays are shown in figures III-15 and III-16. The most significant play in terms of contribution is the Folded Ellesmerian/Pre-Mississippian play, containing approximately 50 percent of the area's estimated in-place oil and 60 percent of the estimated total gas. This play has several unusually large structural prospects and is estimated to contain large accumulations. Next in order of decreasing importance are the Imbricate Fold Belt play and the Turbidite play.

However, in these and several other plays, the estimated accumulation sizes, though perhaps substantial, are often of such size as to be of little or no current economic interest if occurring singly, and are often mapped with great difficulty. If occurring above deeper and larger deposits or close to them, such accumulations may be of interest.

Economically Recoverable Oil Resources

~ The estimate of economically recoverable oil resources for the 1002 area represents an assessment of only the structural prospects which were identified on the basis of the seismic interpretation (fig. III-1). As noted above, the 1002 area is expected to contain a very large additional volume of oil and gas in numerous smaller structurally controlled accumulations (for example, the Imbricate Fold Belt play) and large stratigraphic accumulations (Topset play). The economically recoverable resource estimate should be viewed as an "identifiable minimum" volume, which is constrained by economic and technical recoverability considerations. ~

Conditional estimates of potential economically recoverable oil resources were calculated for use in environmental analyses and to assess the potential contribution of the 1002 area to the Nation's domestic energy supply. These estimates are conditional upon the occurrence of at least one economic-size oil accumulation in the area, the probability of which is about 19 percent. The estimates are reported as a range of values, which reflects the uncertainty inherent in such estimates. The conditional mean estimate was used to provide a single point value for the indicated purposes.

METHODS

The estimate of economically recoverable oil resources for the 1002 area is the result of a prospect-specific analysis using the computer simulation model PRESTO II. PRESTO is an acronym for Probabilistic Resource Estimates--Offshore, developed and currently used by the U.S. Minerals Management Service for generating petroleum resource estimates for Outer Continental Shelf planning areas. The PRESTO process is described by Cooke (1985).

PRESTO II uses prospect-specific geologic and geophysical volumetric input data for identifiable prospects and produces prospect-specific and areawide resource estimates. The uncertainty in a frontier area is addressed by allowing the user to input geologic risk factors and a range of values for each volumetric input parameter. The PRESTO model also allows for input of a minimum economic-field size. Any field smaller than this economic field size is not counted in either the prospect or area conditional resource estimates.

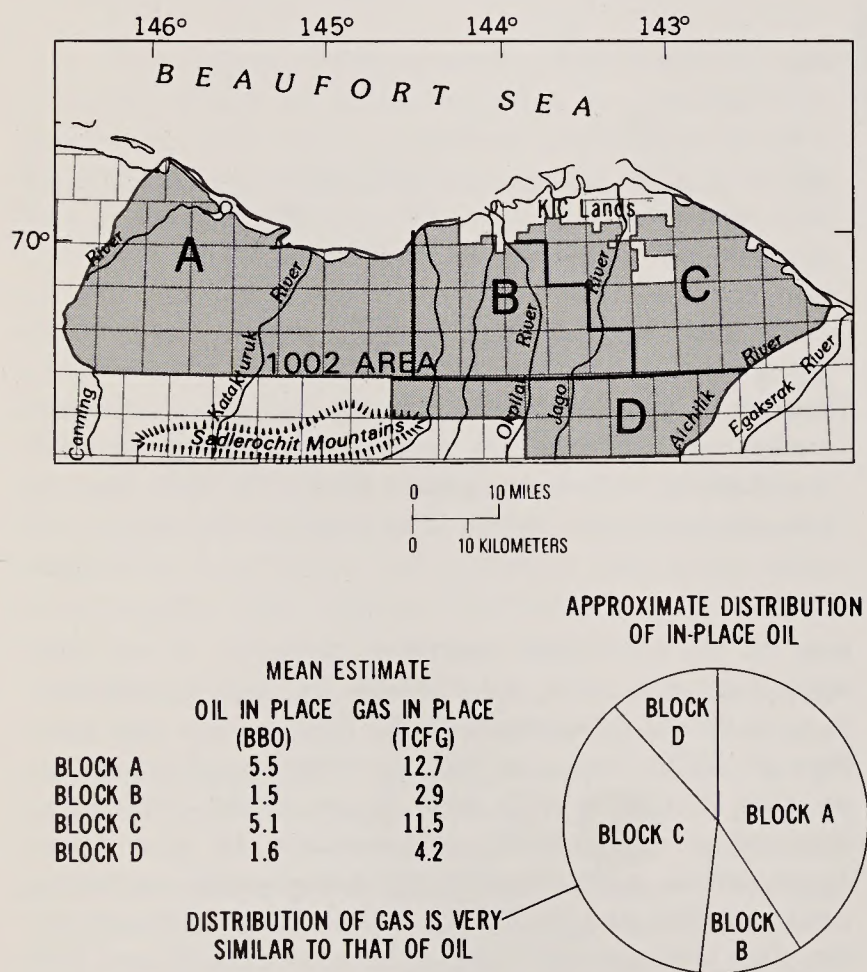


Figure III--14.--Resource blocks A-D of the 1002 area (shaded) and the approximate distribution of mean values of in-place oil and gas resources. (Prepared by the U.S. Geological Survey and the Bureau of Land Management.)

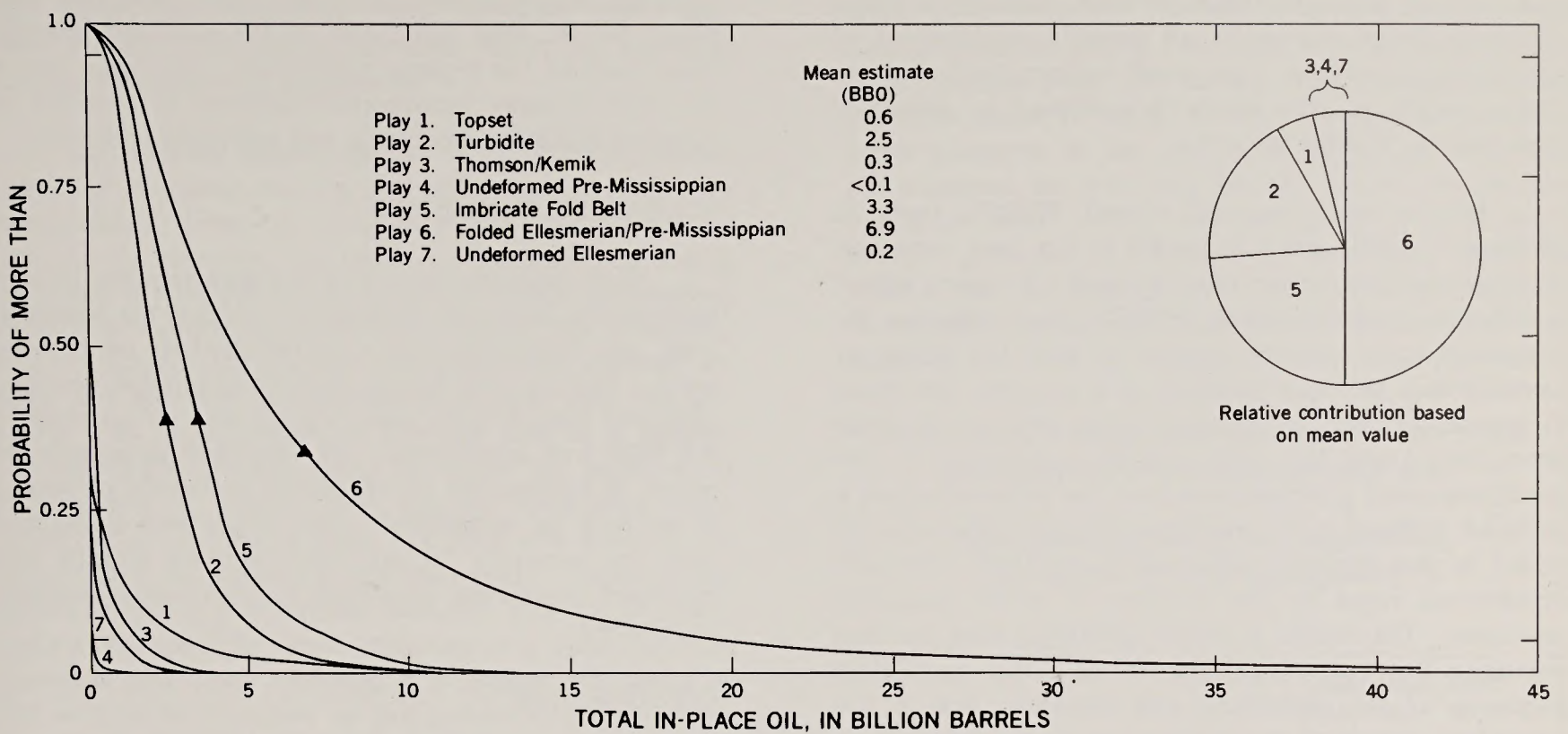


Figure III-15.--Estimated in-place oil for plays in the 1002 area, showing individual probability curves and relative contributions of the plays. Triangles show mean values on principal distribution curves. (Prepared by the U.S. Geological Survey.)

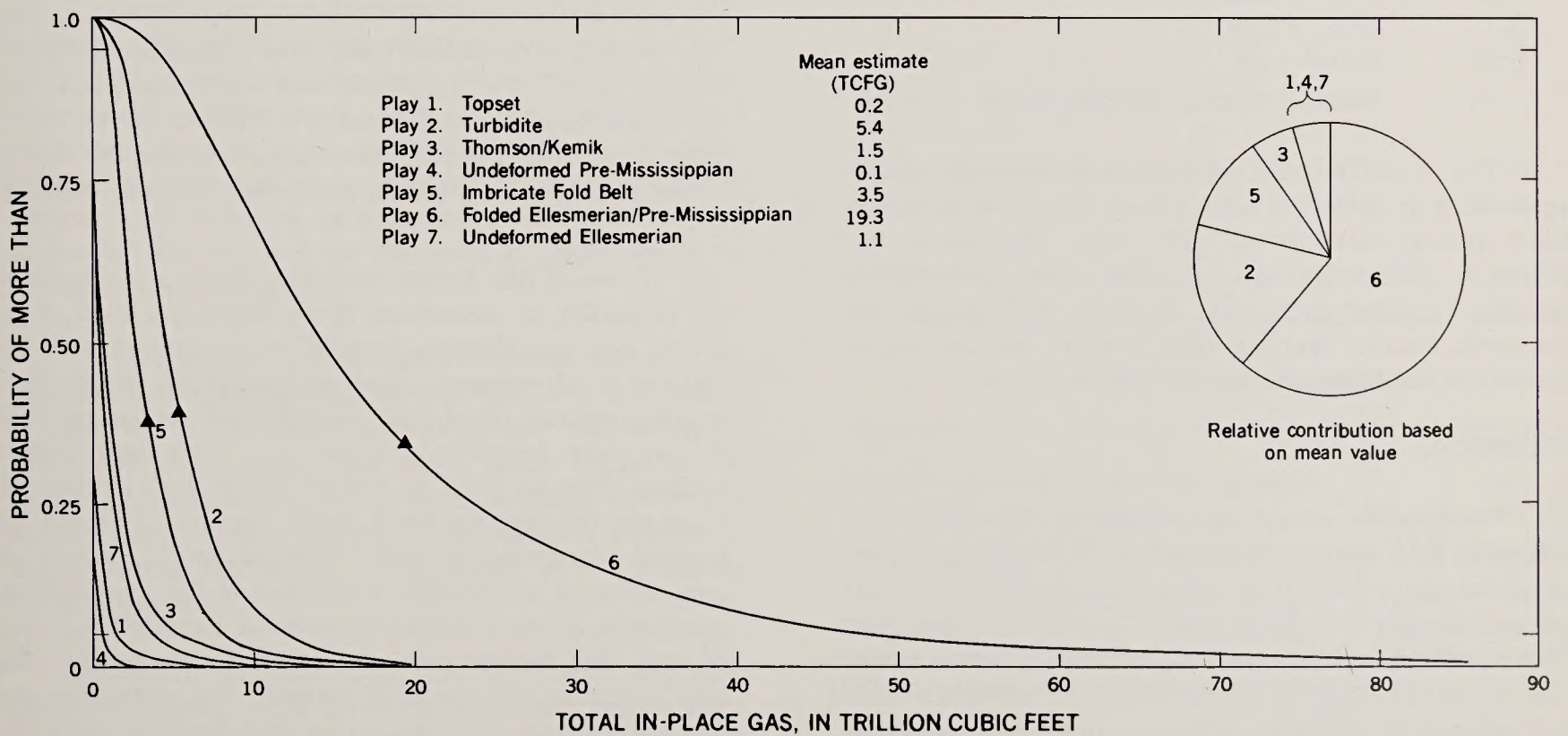


Figure III-16.--Estimated in-place total gas for plays in the 1002 area, showing individual probability curves and relative contributions of the plays. Triangles show mean values on principal distribution curves. (Prepared by the U.S. Geological Survey.)

PRESTO uses a "Monte-Carlo" random sampling technique. The model repetitively simulates an exploratory drilling program for the area, "finding" various combinations of prospects and various combinations of values for volume parameters in the prospects for each simulation "pass." This process, if repeated enough times, results in a range of values which represents all possible combinations of subsurface conditions that affect hydrocarbon volumes. Similar models and the Monte-Carlo method are described more fully by Newendorp (1975).

After all input data are entered, PRESTO starts its simulation, drilling each prospect in the area based on prospect and area risks. After the area has been "drilled" a sufficient number of times, PRESTO then computes the prospect-specific resource volumes for each trial where, by sampling from the input distributions, a prospect was found to be economically productive. The average of these productive trials for each individual prospect is the conditional mean prospect resource. For each trial where a prospect is found to be productive, prospect resources are added to give areawide resources for that trial. The area conditional mean is the average of these area-wide resources. The results of all the productive trials are then arranged in ascending order to give the cumulative frequency of the conditional area resources, that is, the percentage chance of finding resources greater than a given value. The results of all trials (including zero, non-economic, and productive trials) are used to generate risked resource estimates and an economic risk factor (Cooke, 1985, p. 11).

PRESTO MODEL INPUTS

The PRESTO model requires the development of user input values in much the same way as described for the in-place resource assessment. The major difference is that volumetric parameters and risk factors are developed for specific, identified prospects, and that technological and economic factors affecting recoverability are considered. Specific variables are discussed in this section.

PROSPECTS

Twenty-six structural prospects, identified and delineated as a result of interpretation of seismic data, were considered in the 1002 area recoverable resource assessment (fig. III-1; table III-2). The minimum areal size of prospects is a function of the seismic grid density and the resolution (quality) of the data on seismic record sections, which is variable within the area. A large volume of additional, possibly economically recoverable resources in small structural traps and stratigraphic traps may also be present, as reflected in the in-place resource assessment.

ZONES

Each prospect is modeled as having one or more prospective reservoir zones. For the purpose of the 1002 area recoverable resource assessment, the number and geologic characteristics of zones within prospects were based on the areal distribution of the equivalent geologic plays used for the in-place assessment. The major part of the economically recoverable estimate is modeled as occurring in Ellesmerian clastic and carbonate reservoirs.

VOLUMETRIC PARAMETERS

Each reservoir zone in a prospect requires input of hydrocarbon volumetric parameters, including the productive area, pay thickness, and a barrel/acre-foot oil recovery factor. Gas recovery factors and the associated gas input parameter (gas-oil ratio) were "zeroed out" for purposes of the 1002 area assessment. All volumetric parameters are ranges of values, with an associated probability distribution to account for uncertainty. The ranges and distributions used for recovery factors were derived directly from equivalent parameters developed for the in-place resource assessment.

GEOLOGIC RISK

The probability of occurrence of hydrocarbons in an area or prospect is normally expressed as a geologic risk factor which is the complement of the probability of occurrence (1 minus probability of occurrence). It is the probability that hydrocarbons will not be found.

The PRESTO model requires user input of unconditional risk factors for the area and for each prospect and each zone being assessed. At the prospect and zone levels, these risk factors are internally adjusted by the model to a conditional basis, and these conditional risk factors control the frequency with which prospects and zones are found productive during a PRESTO "run" (Cooke, 1985, p. 9). This sampling frequency determines the relative contribution of each prospect to the area resource estimate.

~ Prospect risk factors were assessed on the basis of the probability of occurrence of significant quantities of oil, taking into consideration probabilities associated with the occurrence of minimum values and probability distributions for the reservoir parameters used for the various plays in the in-place resource assessment. New field wildcat success rates for the U.S. and for Alaska were considered. Prospect risk factors used range from 90 to about 98 percent, depending on such prospect specific factors as data coverage and quality, confidence in the interpretation, confidence in the existence of reservoir horizons, and type of trap. The average prospect risk value used for the 1002 area prospects was about 95 percent. For perspective, the reported national average for new field discovery wells has been about 16 percent for the years 1972-1985, but the average size of discoveries included in these statistics has probably been less than 1 million barrels, while the

conditional mean size of the smallest prospect assessed in this analysis was about 20 million barrels (recoverable). For Alaska, from 1982 through 1985, two new field discoveries have been announced for 106 exploratory wells drilled, or about 2 percent (Jones, 1983; Jones and Hiles, 1984; Boyd and Hiles, 1985; Steenblock, 1986; Johnston, 1983, 1984, 1985, 1986). The Alaska statistics reflect the economic realities of a high-cost environment. ~

~ As generally defined for use in the PRESTO model, area risk is based on the probability that at least one accumulation exists as modeled in the area. For this analysis, the area risk was based on the probability that at least one of the five largest prospects exists as modeled. Based on individual prospect risk factors, this probability was 30 percent (70 percent area risk). The rationale for using this approach is that there must be at least one field in the area large enough to bear the cost of a regional transportation infrastructure in order for commercial development to occur. This may be considered overly conservative, in that it does not take into account the possibility of offshore development. Commercial development in the eastern Beaufort Sea would lower regional transportation costs, resulting in a lower minimum economic field size. However, it is beyond the scope of this analysis to speculate on the probability of commercial development in the eastern Beaufort Sea. ~

ECONOMIC INPUTS

The economics of petroleum development for the area and for each prospect are applied in the PRESTO analysis. This is accomplished by means of an estimate of the volume of recoverable resources that would be required for a prospect to be economically successful. This estimate, referred to as the minimum economic field size (MEFS), is based on estimated development, production, and transportation costs, and various forecasts and estimates of future economic factors, such as oil prices, inflation, and discount rates. Pertinent assumptions used in the derivation of MEFS for prospects in the 1002 area are shown in table III-3 and are discussed at greater length by Young and Hauser (1986).

Under the most likely case economic scenario, the minimum economic field size for the 1002 area as a whole is about 440 million barrels of economically recoverable oil. For individual prospects, the MEFS varies, depending on prospect-specific characteristics such as drilling depths, well spacing, and pipeline distance. The areawide minimum is equal to the MEFS for the prospect with the lowest development costs.

Minimum economic field sizes were also calculated using alternative, more optimistic economic assumptions. Under these assumptions, the areawide minimum economic field size (that is, least costly prospect) is about 155 million barrels of technically recoverable oil. This is referred to as the "most favorable case MEFS."

~ Sensitivity analyses were conducted to determine effects of variations in several economic parameters, including oil prices, on the economics of "typical" prospects in the western and eastern parts of the 1002 area. The lowest oil price modeled was \$22 (year 2000 price, 1984 dollars). The MEFS for the eastern Arctic Refuge prospect using this price is more than 2 billion barrels (recoverable). For western Arctic Refuge, the MEFS would be about 1.4 billion barrels. Minimum field sizes for actual prospects in the 1002 area, using this price, were not estimated, but it is likely that the minimum for the area would be close to that for the "typical western Arctic Refuge" prospect (1.4 BBO). All else being equal, the effect of this would be to lower the marginal probability for commercial hydrocarbons from the 19 percent most likely case. ~

Table III-3.--Undiscovered, conditional, economically recoverable oil resources in the 1002 area.

[BBO, billion barrels of oil. Prepared by the Bureau of Land Management]

	Greater than	Economic scenario	
		Most likely case	Most favorable case
A. Conditional, economically recoverable oil			
Probability	99%	0.49 BBO	0.18 BBO
	95%	.59	.23
	75%	1.12	.67
	50%	2.21	1.49
	25%	4.24	3.67
	5%	9.24	7.85
	1%	17.19	15.73
Maximum simulated oil		22.34	22.34
Mean (arithmetic average)		3.23	2.66
Marginal probability ¹		19.0%	26.0%
Minimum economic field		0.44 BBO	0.15, BBO
B. Significant economic assumptions			
Crude oil market price (1984 dollars/ barrel in year 2000)		\$33.00	\$40.00
Annual inflation rate		6.0%	3.5%
Discount rate:			
Real		10.0%	8.0%
Nominal		16.6%	11.78%
Federal royalty rate		16.67%	12.5%
Development cost multiplier		1.0	0.75

¹The marginal probability is the probability of occurrence of economically recoverable oil somewhere in the 1002 area.

PRESTO ANALYSIS RESULTS

Economically recoverable estimates of oil resources were calculated using two economic scenarios. The results and economic variables that significantly affect the estimate of the minimum economic field size are shown in table III-3.

The most favorable case resource estimate was made to assess the effects of different economic conditions or projections on the estimate. Except for economic inputs (the minimum economic field size), all other variables were held constant. On a conditional basis, the area resource estimate is lower because the prospect resources contributing to the area resource are lower. The range of values for each prospect modeled is truncated at a lower level by the lower minimum economic field size, resulting in a wider range of conditional values containing lower values. This is offset by the increased marginal probability of occurrence associated with the wider range of values, because prospects and the area are found economic more often during the Monte Carlo simulation (Cooke, 1985, p. 11).

To assess the effect of variations in geologic risk, PRESTO runs were made at different levels of unconditional risk. These runs produced no significant variations in the conditional area resource estimate.

~ MARGINAL PROBABILITY ~

The marginal probability is an output of the PRESTO model that indicates the chance that an area having the characteristics specified by the inputs will contain at least one field with economically recoverable resources. The input parameters which most directly affect this output are the area geologic risk (a function of the individual prospect geologic risks) and the minimum economic field size estimated for each prospect (see "Economic inputs," this chapter).

As a consequence of the area geologic risk, the results show a 30-percent chance that an exploratory drilling program would find hydrocarbons. There is a 63-percent chance that, if hydrocarbons are found, the amount would exceed the minimum economic field size for at least one prospect, resulting in the marginal probability of 19 percent. Stated another way, assuming 1,000 areas similar to the 1002 area, 300 would have hydrocarbons and 190 of these would have at least one prospect containing resources exceeding the minimum economic field size.

The statement that there is a 19-percent chance of finding recoverable oil in the 1002 area needs to be interpreted in light of past experience in oil exploration and resource assessment. Generally speaking, the marginal probability of finding oil will be lower, the smaller the unexplored area being considered. The 19-percent probability for the 1.5-million-acre 1002 area thus indicates a very high potential when compared to the 27-percent probability for the 37-million-acre Navarin Basin or the 22-

percent probability for the 70-million-acre St. George Basin (table III-1). Furthermore, the marginal probability of finding a recoverable field will be lower, the greater the minimum economic field size, because, as discovery statistics show, the number of fields of a given size is much lower for larger fields. There are fewer 1-billion-barrel fields than 100-million-barrel fields. Because of the high cost of operations in the Arctic, the minimum economic field size is 440 million barrels, which is much higher than for areas in the lower 48 States. Despite this high threshold, the chance of finding a recoverable field in the 1002 area is 19 percent. This shows an exceptionally high potential for oil and gas. For perspective, in 1982, 1,402 new-field discoveries were reported for the United States, but only 652 million barrels of hydrocarbon liquids were discovered in the new fields.

RESOURCES BY BLOCK

To provide a basis for assessing the consequences of management decisions in terms of the oil resource potential of the 1002 area, the unconditional resource potential for the area was allocated on a percentage basis to the blocks shown in figure III-14. This allocation is based on the unconditional resource potential of the individual prospects contained in each block. See figure III-1 and table III-4. A similar resource allocation, by percentage, was made to "activity areas" in Section 105(b) Economic and Policy Analysis for the National Petroleum Reserve in Alaska (U.S. Department of the Interior, 1979).

Table III-4.--Distribution, by block, of estimated unconditional mean recoverable oil resources in the 1002 area. (Prepared by the Bureau of Land Management.)

Block	Location in 1002 area	Resource distribution (percent)	Number of prospects in block
A.....	West	9	14
B.....	Central	3	3
C.....	East	63	4
D.....	South	25	5

NATURAL GAS ECONOMICS

~ For this analysis, crude oil is assumed to be the only potentially economic hydrocarbon in the 1002 area which would attract development interest in the mid- to late-1990's, and which could be explored for, developed, and marketed within the 30-year timeframe at expected costs and prices. This study recognized four factors: (1) the high costs of North Slope natural gas at market, (2) uncertainty that any gas transportation system will be developed for the North Slope, (3) additional costs of transporting gas from the 1002 area to the northern terminus of such a pipeline, and (4) the quantity of known reserves elsewhere on the North Slope that would presumably be developed before the 1002

area. Therefore, this analysis assumes that there will be no demand for acquiring acreage in the 1002 area in the early to mid-1990's for seeking and producing natural gas, and further, that any gas discovered through oil exploration will remain undeveloped or will merely be used locally for fuel. ~

It is assumed that any gas resources discovered through oil exploration activities will remain undeveloped or will be used locally, although potential gas resources in the 1002 area are not without value. At some future time, national or international economic conditions or technological advances may warrant exploration for and development of potential natural gas resources in the 1002 area. For a detailed discussion of the alternatives and issues affecting development of potential natural gas resources in the 1002 area see Young and Hauser (1986).

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OIL-FIELD DEVELOPMENT

CHAPTER IV

DEVELOPMENT AND TRANSPORTATION INFRASTRUCTURE

INTRODUCTION

~ Section 1002(h)(3) requires an evaluation of the effects of further oil and gas exploration, development, and production, should it be permitted on the 1002 area. Section 1002(h)(4) requires a description of oil and gas transportation facilities. To meet these requirements, scenarios were needed to describe possible oil and gas development within the Arctic Refuge coastal plain, and transportation of the oil and gas to processing facilities. The scenarios in this chapter are based on general concepts germane to oil development and production in an arctic environment. Advances in arctic engineering and oil-field development and/or site specific factors in the 1002 area may allow for the construction of smaller pads and roads requiring less gravel than those described in the following scenarios. Determining the possible magnitude of such development in the 1002 area required an estimate of the amount of potentially recoverable hydrocarbon resources. Chapter III describes how these recoverable resource estimates were derived, and the limitations connected with their use. ~

Gas was not considered in the recoverable resource assessment; at present crude oil is assumed to be the only potentially economic hydrocarbon which would attract leasing interest if the 1002 area were opened to leasing. Conceivably, at some future date, gas as well as oil could be economically produced from the Arctic Refuge. Therefore, a general discussion of gas development and transportation is presented at the end of this chapter.

~ For this chapter and Chapter VI, the recoverable estimates used are those attributed to the mapped structures (fig. III-1). This is not to imply that these are the only areas of oil and gas potential on the 1002 area. It merely provides a less speculative tool from which to project potential development activity and from which to evaluate possible environmental impacts. Areas outside mapped structures may prove to be of greater, lesser, or equal potential. Without exploratory drilling as a confirmation and delineation tool, all estimates must be considered uncertain. Of course, if no oil is present, there will be no impacts from development and production. ~

EXPLORATION, DEVELOPMENT, AND PRODUCTION

~ The exploration and development of an oil field on the North Slope of Alaska and the transportation of oil to markets entail several activities and the construction of many types of facilities. The various activities include seismic exploration; drilling of exploration, confirmation, delineation, and production wells; and the planning, engineering, and construction of field production facilities, support facilities, and transportation systems. Following is a general description of the activities and facilities that would normally be required to transport North Slope oil from the 1002 area to market. The exploration, development, and construction scenarios presented herein are general concepts and must not be considered to be final engineering solutions for oil and gas production from the 1002 area. ~

Exploration

ADDITIONAL GEOLOGICAL AND GEOPHYSICAL EXPLORATION

Additional surface geology work would probably occur prior to drilling exploratory wells. This would consist of hand sampling of rock and further study and measurement of geologic sections. Access would be by helicopter, and actual time on the ground would be only a few hours for each survey.

Additional seismic exploration would also take place to obtain more detailed information on subsurface geology. Use of vibrator equipment would probably be the preferred method, based on the results of seismic activities already conducted in the 1002 area. Although the total line miles of new surveys might not differ much from the cumulative total of about 1,300 line miles already collected, more crews may be on the area for two reasons: (1) different companies have different ideas as to where to concentrate detailed surveys (closer grid spacing); and (2) different types of data and parameters are useful to companies in their interpretations of subsurface geological structures or style. Thus, there could be requests for authorizations to run "3-D surveys," which use closely spaced, parallel survey lines.

EXPLORATORY DRILLING

~ Exploratory drilling is a large-scale operation using heavy equipment, but it is usually confined to a localized area. For environmental, engineering, and economic reasons, exploratory drilling on the North Slope is typically conducted during the winter. If exploratory drilling operations, including construction, drilling, and testing, can be completed within approximately 170 days, a well can probably be completed in a single winter season (Mitchell, 1983b). On the North Slope, exploratory wells to a moderate depth can usually be drilled in a single season, whereas most deep wells (deeper than 10,000 feet) would require two seasons. Decisions to allow year-round drilling activity will be made on a case-by-case basis. ~

A single-winter-season operation involves the mobilization of construction crews and equipment, followed by the mobilization of the drilling rig. After the rig and support equipment are delivered to the site and assembled, drilling begins, and continues until the desired depth is reached. After drilling, testing, and suspension or abandonment of the well, the rig, support equipment, and camp are demobilized and the pad area is rehabilitated.

Construction equipment is hauled cross-country by low-ground-pressure vehicles to the exploratory well site. Once the equipment and crew arrive on site, construction begins for ice roads, an ice airstrip, and the drilling pad. The drilling rig and the ancillary equipment can be transported overland by low-ground pressure vehicles or flown in by C-130 aircraft.

~ The drilling pad can be constructed of ice, excavated material, gravel-foam-timber, or other possible combinations. The pad is large enough to hold the rig, camp, and support equipment, and to provide storage for drilling supplies (drillpipe, casing, drilling mud, cement, etc.). A typical pad (including reserve pit) covers 5-10 acres of ground surface. The construction and drilling camps contain sleeping and eating accommodations, communication equipment, power generator units, storage space, shops, and offices. An initial construction camp contains facilities for 50-75 people and the drilling camp for 50-60 people. The actual number of people varies with the type of activity. ~

~ A reserve pit is excavated at the edge of the pad immediately adjacent to the well. The purpose of a reserve pit is twofold: (1) to contain the used drilling muds and "cuttings" from the well, and (2) to contain formation fluids originating from a "kick." ~

~ Reserve pits generally cover 0.5 to 2.0 acres (parallel to the drilling pad); they are 10 to 20 feet deep. A small flare pit is excavated at the corner most distant from the drilling rig, in case it is needed for gas flaring during testing. The material excavated from the reserve and flare pits is used to level the drill pad, providing a cover

averaging 2 feet deep over the tundra surface. This material is used to backfill the reserve pit upon pad abandonment. ~

The drilling pad is connected to the airstrip and the camp water source by ice roads. Initially a source of water sufficient for ice-road and airstrip construction and camp and drilling uses must be located. Water in the 1002 area is confined to surface resources, and there are few lakes of appreciable size within the area. The water requirements for drilling an exploratory well are approximately: (1) 1.7 million to 2.0 million gallons for the drilling operations and domestic use, (2) 1.2 million to 1.5 million gallons per mile for construction and maintenance of ice roads, and (3) 7 million to 8 million gallons for construction and maintenance of an airstrip on the tundra. Therefore, as much as 15 million gallons of water may be needed to drill one exploratory well.

~ The limited availability of fresh water on the Arctic Coastal Plain, particularly in winter, is not a problem unique to the 1002 area. The various sources used and methods developed to satisfy water requirements in other areas in the Arctic (the Prudhoe Bay development area near the mouths of the Sagavanirktok and Kuparuk Rivers to the west) will be applicable to activities in the Arctic Refuge. Just as water availability varies by location, solutions to providing/obtaining water will have to be considered on a site-by-site basis. The several sources and methods used to obtain winter water supplies in earlier exploratory development and production activities in Arctic Alaska are mentioned elsewhere in this report. These include existing naturally deep lakes and deep pools along rivers that do not freeze to bottom in winter; melting lake and river ice, including large aufeis deposits downstream from the several large springs south of the 1002 area (Childers and others, 1977), trapping and melting snow; creating water reservoirs by excavating deep pools in lakes or along stream channels in conjunction with gravel removal operations; and desalinating marine waters obtained beyond the barrier islands. ~

If a suitable water source can be found, ice roads would probably be constructed, typically by applying a layer of water over snow cover along the desired route, using specially designed water trucks. This process is repeated until an ice layer of sufficient thickness is created. One mile of ice road generally requires about 1.5 acre-feet of water. Ice airstrips are usually placed on nearby lakes if they are of sufficient size; otherwise, the airstrip is constructed on level tundra in a manner similar to an ice road except with a minimum ice thickness of 12 inches. The airstrip may be as long as 5,000-6,000 feet and about 150 feet wide, usually to accommodate Hercules C-130 aircraft.

Drilling operations begin by augering a hole typically 50-100 feet deep for the conductor casing. Then the drilling rig is placed on the pad. To prevent differential settling during drilling, the rig is placed on pilings or

timbers. The conductor casing is run and cemented in place and the well is spudded. Drilling begins and the hole is drilled to a competent geologic formation, usually to a depth of about 2,000 feet. Test logs are run and the surface casing is run into the hole and cemented with a special arctic cement. This casing passes through the entire permafrost zone and provides an anchor for blowout-prevention equipment until the next casing string is set. Drilling continues to the next casing point where the well is logged and intermediate casing is run and cemented. Drilling continues until the target zone is reached and tested. After final testing and logging, the well is suspended or abandoned by placing several cement plugs in the well bore and casing.

Usually demobilization of the drilling rig and camp starts immediately after the well is abandoned. Within several weeks, the equipment and most of the debris will have been removed or the equipment made secure for movement to the next wellsite. A final-cleanup crew returns to the site in the summer to pick up any remaining debris or garbage and to check on the rehabilitation.

For wells that cannot be completed in a single winter season two options exist: (1) year-round drilling or (2) interrupted drilling during two or more winter seasons (Mitchell, 1983a). Year-round exploratory drilling uses the same facilities as the winter method, but the pad, roads, and airstrip are usually constructed with gravel instead of ice. Therefore, a source of gravel for construction material must be available.

~ Multi-winter drilling is similar to single-winter drilling, except that a portion of the drilling pad is constructed with enough gravel to provide a stable and suitable surface on which to store the drilling equipment and camp during the summer. A wood and timber drilling platform or base may be an alternative to using gravel. At the end of the first drilling season the well is freeze protected with a low-freeze-point fluid and suspended. At the beginning of the second or subsequent winter drilling seasons, the roads, airstrip, and drilling pad are rebuilt to the extent necessary with ice, the low-freeze-point fluid in the upper part of the well is removed, and drilling is resumed. ~

Development

Following a discovery of oil from exploration drilling, a confirmation or delineation well is drilled. This well tests the same prospect and is drilled in a similar manner as an exploration well. If the well results are positive, further delineation drilling occurs. The purpose for delineation drilling is to determine the size of the discovery and the geologic characteristics of the reservoir. Delineation drilling continues until enough information has been collected to determine whether or not the reservoir could be produced economically. The actual number and scheduling of delineation wells are tailored to each reservoir. The drilling method is similar to that for discovery and confirmation wells except that two or more wells might be drilled during

the same winter. If so, the airstrip, roads, and pad for support of the drilling rigs could be shared. If the discovery is significant and appears to be economically developable, some of the roads and delineation-drill pads may be constructed with gravel so they could be used during production.

From time of discovery through delineation, evaluation, and engineering, the lessee or lessees conduct environmental studies and plan for the development and production of the reservoir. Once the studies and plans are completed, the lessee's plans for construction, development, and production are submitted to appropriate Federal and State agencies for review, possible modification, and approval.

Assuming that the decision is to proceed with development and that plans of operation are approved, the first on-the-ground activity is establishment of a temporary construction camp for workers. This camp provides the necessities for living and working on the North Slope and may house as many as 1,500 workers during peak construction and development. Gravel extraction and construction of roads, drilling pads, and airstrip are priorities, because these facilities receive immediate and continuous use. First to be constructed is the airstrip to handle the heavy supply loads. With connecting roads, such an airstrip could serve several oil fields, were others to be discovered nearby. Next would be gravel roads to planned drilling pads, and then all-season pads. Construction would begin at the main camp, again with an all-season gravel pad. Once each pad is completed, drilling rigs can be moved on location and production drilling can begin.

The buildings and engineering equipment for the permanent camp and most of the production facilities are usually constructed as large modular units elsewhere (lower-48 States, Anchorage, etc.). The modules, often several stories high, are sent by barge on an annual sealift during the open-water season to a suitable port site having large-scale dock facilities. From there, they are either trucked or moved by tracked vehicles to the project location. On-site the modules are assembled and functionally tested. The actual years of construction may depend on the overall scope of the field development and is usually a continuing operation. For example, construction was begun on the Prudhoe Bay field during the early 1970's, yet major construction supported by annual sealifts has continued into the 1980's with expansion of the initial production field and improved technology for extraction of additional petroleum resources. Construction may continue for many more years.

Construction of a hot-oil transmission pipeline presumably to TAPS (Trans-Alaska Pipeline System) Pump Station 1 at Prudhoe Bay would proceed concurrently with construction of production facilities (see "Transportation options for oil and gas production," this chapter).

Once the major production facilities, including gathering pipelines and main pipeline, are in place, production begins. The initial production rate depends upon the number of production wells drilled and connected to production facilities; peak production is probably attained in 2 to 5 years, and expected to be 5-10 percent of total recoverable resources annually. Production may remain at that level for 3-8 years and then decline 10-12 percent per year. The productive life of an oil field is usually 20-30 years (National Petroleum Council, 1981). After production from the reservoir is no longer economic, the field would presumably be abandoned, although this has not yet occurred on the North Slope. Most facilities, buildings, structures, equipment, and above-ground pipelines would be removed to permit rehabilitation of the surface.

The time period from lease acquisition to initial oil production from a new reservoir on the North Slope is difficult to determine. Even under optimum circumstances, about 10 years will elapse before production starts from a new lease.

Production

The physical characteristics (size, shape, depth) and performance (spacing and production rate of wells) of a field determine the number and location of surface facilities needed for development and production.

The size and shape of the productive field roughly define the areal extent of surface disturbance from production-related facilities. The lateral dimensions of the reservoir, projected to the surface, would typically encompass all or most of the production facilities such as drilling pads, reserve pits, infield roads, and gathering lines. The camp, airstrip, or other facilities not directly related to actual production could be positioned to best suit environmental and engineering concerns.

For environmental or technical reasons, it may be desirable to shift the location of the drilling pad. Directional drilling allows multiple wells to be drilled from a single gravel pad (fig. IV-1). This typical North Slope practice reflects economics, engineering considerations, and environmental impact mitigation. A vertical hole is drilled to a predetermined "kickoff" point where a controlled deviation (drift) from vertical is begun. The angle of deviation increases with depth until it reaches the necessary angle for the well to reach a specific bottom-hole location in the producing geologic formation. The horizontal deviation (horizontal distance between surface and bottom-hole locations) depends upon the angle of deviation and the vertical depth of the hole. The amount of horizontal deviation that is possible for a group of wells drilled from a single pad determines the degree of flexibility in choosing the surface location of that drilling pad. Increased true vertical depth of a reservoir increases the degree of flexibility in pad location.

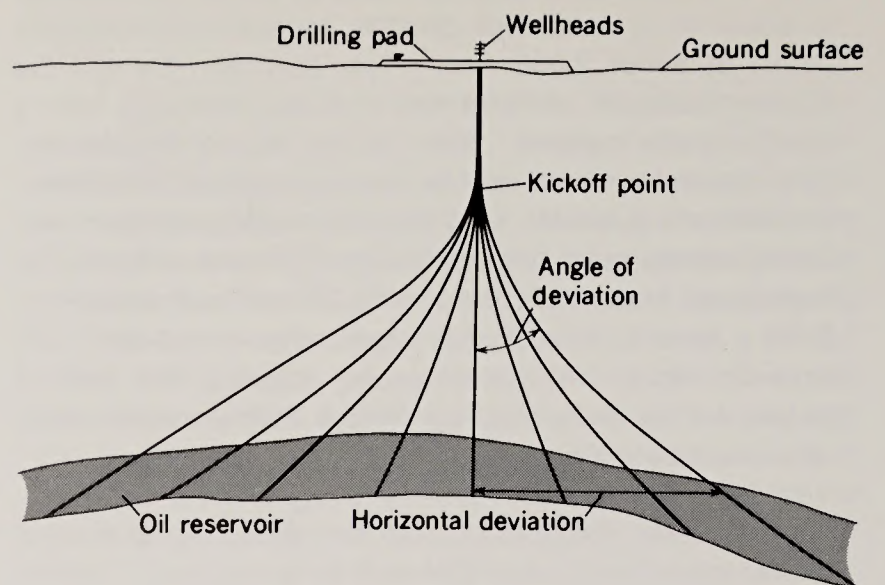


Figure IV-1.--Directional drilling from a single location.

~ Unless advances in technology dictate otherwise, most development wells for the 1002 area would likely be drilled with an angle of deviation between 0° and 60° from an assumed kickoff point as shallow as 500 feet. The actual kickoff point depends upon geologic conditions and reservoir depths. The maximum practical angle for directional drilling on the North Slope is now about 90° , with the horizontal deviation reaching a possible distance of more than 12,000 feet in some of the deeper reservoirs (that is, deeper than 10,000 feet) (U.S. Army Corps of Engineers, 1984). ~

Reservoir depth also influences the number of drilling pads required for development and production. A deep reservoir can be produced from fewer drilling pads because more wells can be drilled from a single pad (fig. IV-2). Conversely, a shallow reservoir requires more drilling pads, because fewer wells can be drilled from each pad.

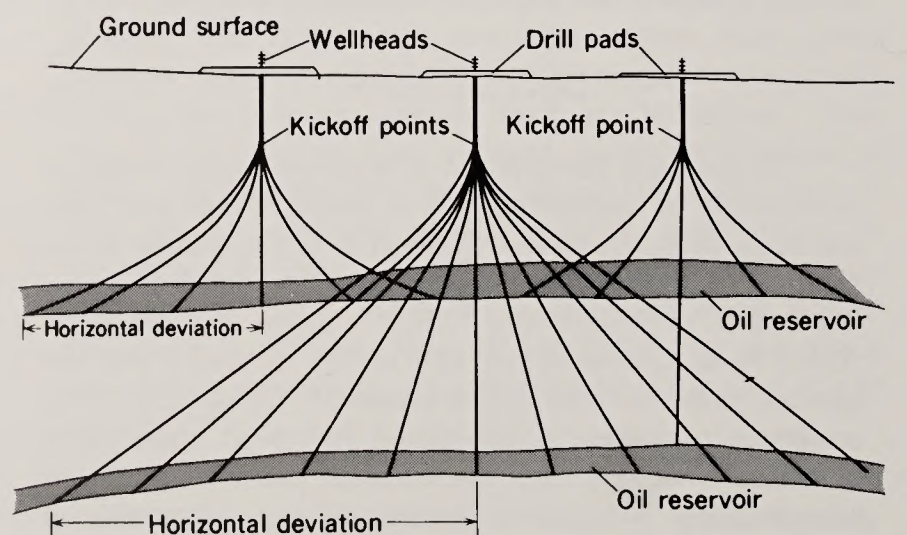


Figure IV-2.--Horizontal deviation versus well depth.

~ Reservoir type and performance influence the spacing of production wells, which in turn affects the number of drilling pads required for development and production. The well spacing for a producing field is designed to effectively drain a specific area surrounding the well bore. On the North Slope, well spacing, or well density, ranges from 1 per 5 acres (West Sak Pilot Project) to 1 per 320 acres (initial Prudhoe Bay development), depending on production performance and needs (Williams, 1982; Petroleum Information Corporation, 1985). ~

Production drilling on the 1002 area is assumed to be on 160-acre spacing, the present practice in portions of producing fields on the North Slope and the spacing herein assumed for the development scenarios and the minimum economic field size determinations. Each production well would then drain 160 acres. This spacing is "reservoir spacing" in the subsurface and should not be confused with surface well spacing. Also, if gas were to be produced, reservoir spacing would probably be greater (320 or 640 acres). Injection wells are required for fluid disposal, gas reinjection for storage and pressure maintenance, and waterflooding for pressure maintenance.

~ Infrastructure for any oil production on the 1002 area requires many facilities, like those for the Kuparuk River and Prudhoe Bay oil fields (U.S. Army Corps of Engineers, 1984; Andrews, 1984). These major facilities include central production facilities, drilling pads, roads, airstrips, pipelines, water and gravel sources, base camps, construction camps, storage pads, powerlines, powerplants, support facilities, and possibly a coastal marine facility. All would be of permanent construction and have a useful life of 30-50 years. The airstrips, roads, pads, and dock facilities would typically be constructed of gravel mined from nearby upland sites, terraces, or streambeds. Most structures and production facilities would be built off-site as modules and transported to and assembled on location. ~

CENTRAL PRODUCTION FACILITY

~ The central production facility (CPF) is the primary operation center for production activities and may possibly be the headquarters for each field. Typically the CPF includes: production facilities; living quarters and administrative office center; workshops, maintenance buildings, and garages; fuel and water storage; electric-power-generation unit; solid-waste and water-treatment facilities; and a crude-oil topping unit, if needed. ~

If the field being developed is small, all facilities may be located on a single gravel pad. However, field sizes in the 1002 area may be on a scale similar to Prudhoe Bay or Kuparuk River. This would require locating some facilities on separate pads, and additional CPF's could be necessary. Pad size varies according to the magnitude of the field, good arctic engineering practice, and environmental concerns. Each pad would be about 5 feet thick and could cover 20-100 acres, requiring 180,000-900,000 cubic yards of gravel. Actual pad thickness

depends on the amount of insulation necessary to protect the permafrost from thawing, but a 5-foot thickness should provide the needed insulation for most of the 1002 area. Structures would be built on pilings and elevated above the pad surface to ensure foundation integrity for the project life.

Living quarters must provide sleeping accommodations, kitchens, food storage, dining areas, sanitary stations, and recreation facilities for all production, maintenance, and administrative personnel at the CPF, about 200-500 people depending on the magnitude of operations. Support services, administration, engineering, communications, and project management would be housed in an adjacent administrative office center. The workshop, maintenance center, and main garage would be located nearby, for fire, safety, and oil-spill equipment as well as parts and supplies.

Production facilities include the equipment necessary to process hydrocarbons from the producing wells, beginning with a series of three-phase separators which result in three products--oil, gas, and water. Each product is run through additional separators until the required separation is obtained. Oil is piped through a sales meter and then to the pipeline pump station. The gas is available for on-site fuel requirements or is used for producing additional oil (enhanced oil recovery or gas lift). In gas lift, the separated gas is compressed, returned to the production well, and injected into the space between the casing and tubing, where it enters the tubing through a gas-lift valve. The oil in the tubing mixes with the gas and is raised to the surface by the expanding gas (American Petroleum Institute, 1976). In enhanced oil recovery, any excess gas is injected back into the reservoir through gas injection wells to maintain reservoir pressure.

The separated water is pumped to water injection wells for subsurface disposal or reservoir waterflooding. A waterflood system for secondary oil production would probably be necessary for developing a reservoir in the 1002 area. Waterflooding involves the injection of large amounts of water into the reservoir (400,000 barrels per day for the Kuparuk River field, and up to 2 million barrels per day for the Prudhoe Bay field), and serves to sweep the oil toward producing wells and to maintain reservoir pressure (Lynch and others, 1985). This process increases the recoverable reserves of the reservoir.

Sea water is the likely choice for a waterflood project if sufficient quantities of produced water are not available. A sea-water waterflood system includes a sea-water intake structure and treatment plant, an insulated pipeline from the plant to each CPF, and heat generators spaced at intervals along the pipeline to prevent the water from freezing. The sea-water treatment plant probably would be located at the coast as in Prudhoe Bay (Williams, 1982). For the Prudhoe Bay facility the entire plant was built in a single barge unit towed up during the open-water period and grounded at the prepared coastal site. The treated-sea-water pipeline

would be routed to the CPF where additional pumps would increase the pressure to meet injection needs. The treated sea water would then be piped to the appropriate drilling pads for injection.

~ Fresh water for camp use is normally obtained from various sources--lakes, water-filled gravel pits, enhancement of existing lakes and river oxbows, or by desalination of sea water. Requirements for camp use could be as much as 10,000 gallons per day, and drilling water requirements could be as high as 30,000 gallons per day per well. ~

Data from water-availability studies for the proposed Alaska Natural Gas Pipeline are shown in table IV-1. The data were obtained 12-27 miles inland, approximately in the middle of the 1002 area, and suggest that in winter rivers in the 1002 area are not a potential source of water for industrial use. Note that water depths beneath ice do vary throughout the length of these rivers.

Table IV-1.--Winter water depths at selected locations on the 1002 area.

[Data from U.S. Department of the Interior, 1976, "Alaska" volume, p. 99]

River	Date sampled/observed (1973)	Thickness of ice (ft)	Water depth (ft)	Approximate straight-line distance (mi) upstream
Canning.....	4/18	7.54	0	19.8
	(downstream) 11/05	1.15	0	14.0
Tamayariak.....	11/07	0	0	14.0
	11/07	0	1.15	13.0
Katakturuk.....	11/07	0	0	11.8
Sadlerochit.....	11/07	.03	0	18.9
Hulahula.....	4/18	0	0	21.7
	11/08	0	.82	19.2
Jago.....	4/18	0	0	26.7
	11/07	.85	0	26.7
Okerokovik.....	11/07	0	.66	25.7
Aichilik.....	11/07	2.16	0	19.8

Water sources may include non-fish-bearing streams, rivers, and lakes year round. Water may be removed from fish-bearing waters, except in winter, provided that water removal meets Alaska Statute Title 16 requirements, is within terms of other necessary State and Federal permits, and does not impede fish passage or otherwise measurably degrade aquatic habitats.

Desalinated sea water and snow melting are also options, particularly for domestic use and exploratory drilling operations. These sources may not be economically feasible for ice roads and airstrips. Material sites may also function as water reservoirs and, where possible, could be positioned and designed to fulfill both gravel and water

needs. Potable water for camp use would be stored at the CPF in insulated tanks. Additional water and sewage treatment facilities are normally placed at each CPF.

The fuel-storage area would hold diesel and other necessary refined petroleum products and would be diked to contain any spills. A crude-oil topping plant may provide all the field's needs for arctic diesel and jet fuel, or fuel needs could be transported into the field. An electric generating plant, fueled with produced gas, would provide power for each field. Backup diesel power would be available at all sites for use in power outages.

DRILLING PADS AND WELLS

Each drilling pad would support drilling activities until all the production and injection wells had been drilled. Production from the pad could begin before all wells are completed, so production and drilling may occur simultaneously. The layout of a pad during drilling activities typically includes the following: drilling camp, fuel and water storage, one or two drilling rigs, drilling supplies, reserve pits, production facilities and equipment.

The drilling pad is normally constructed with gravel and covers 20-35 acres. A pad thickness of 5 feet requires 160,000-285,000 cubic yards of gravel. The drilling camp is similar to the camp facilities at the CPF, but smaller and temporary. Housing is required for approximately 50 people per drilling rig, and support staff and some maintenance workers for the production wells. Once initial drilling is complete, the drilling camp is disbanded and remaining personnel are housed at a CPF. Drilling supplies at the pad would include well tubulars, drill bits, drilling mud and chemicals, cement, wellheads, and other assorted equipment.

The wells on the pad are customarily arranged in a straight line; adjoining wells may be as close as 10 feet (U.S. Army Corps of Engineers, 1984). Spacing between wells depends on pad-size restrictions and the number of wells required for each pad. Producing-well design depends upon well-production rates, geologic conditions, and drilling depth. A design example is shown in figure IV-3.

~ Drill cuttings from the well are placed in a reserve pit on the drill pad. Spent drilling muds are generally pumped into the annulus of previously drilled production wells. Hazardous solids and solids containing hydrocarbons must be removed to and safely contained in a government-approved site, such as an abandoned gravel pit. ~

The number of pads required to develop and produce an oil reservoir depends upon reservoir size and depth, the production-well spacing, and number of wells on a pad. These factors cannot be determined until site-specific engineering studies are completed. However, as an example, a relatively deep field of 35,000 productive acres developed on 160-acre production-well spacing may require

approximately 220 production wells and 90 injection wells. If the wells drilled from a single pad could effectively drain 5,000 acres, seven drill pads would be necessary; 40 to 50 wells could be drilled from each pad.

AIRSTRIP

An airstrip to support each major field development and production area in the 1002 area would be a permanent, year-round structure used for the entire lifetime of that field. The airstrip(s) would be designed to accommodate all types of fixed-wing aircraft and helicopters, and have a length of 5,000-6,000 feet and a width of 150 feet. The airstrip(s) would cover approximately 20 acres each; the adjacent taxiway, apron, terminal, and other airport support facilities could require another 10 acres. Airstrip(s) and pad(s) for support facilities would be constructed of gravel and be about 5 feet thick. The estimated gravel requirement for each is approximately 250,000 cubic yards.

FIELD ROADS AND PIPELINES

Gravel roads would connect all permanent facilities in the field (that is, all drilling pads, CPF's, airport complex, water and gravel sources, and waterflood and marine facilities). These roads would have a crown width of approximately 35 feet and a thickness of 5 feet. Each mile of road occupies about 5 acres and requires approximately 40,000 cubic yards of gravel. The number of miles of roads constructed would depend upon the size and physical setting of the field.

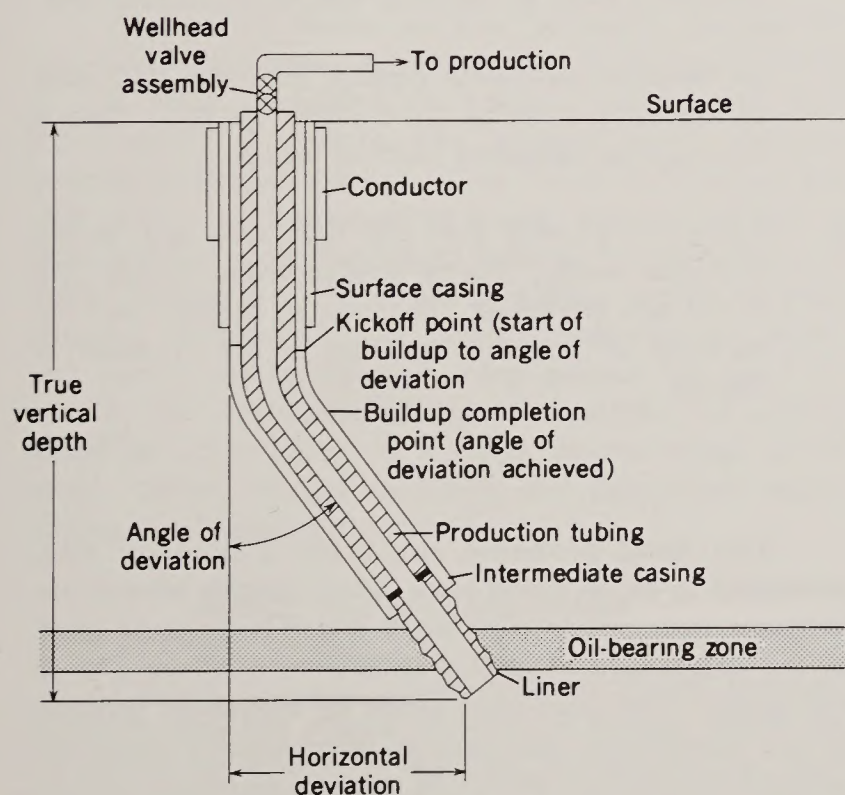


Figure IV-3.--Production-well design.

In-field pipelines or gathering lines would run from each drilling pad to the CPF. Parallel pipelines carry gas and water from the CPF to the drilling pads for fuel, injection, or disposal. The pipelines would probably be 8-24 inches in diameter and be built parallel to the roads connecting the drilling pads and the CPF. They are commonly placed on elevated steel vertical support members (VSM). Pipelines, pump stations, and the VSM's are discussed in more detail later in this chapter.

MARINE FACILITY

A marine facility would be required for major equipment sealifts. The facility built on the coast would take into consideration the locations of the proposed developments and environmental and engineering concerns. As needed, detailed engineering studies would be prepared for the marine facility size, design, and location.

The facility would contain sea-water treatment facilities and various supporting operations. It would be designed to receive barges loaded with the annual sealift of supplies, other cargo, and production/support modules used in the oil field's development and production. Barging these goods with an annual sealift is the most economical method of transportation and the only practical method of delivering very large modules to the North Slope. Barge routes and timing would be similar to the current annual sealift used by North Slope operators.

The facility would require one or more docks and sufficient acreage in storage pads to facilitate orderly and timely unloading of barges. A temporary camp and associated support facilities would be required during unloading periods if the main camp were too distant to provide necessary living quarters for marine facility workers. A transportation corridor would be required to connect the marine facility with the development site.

~ Camden Bay and Pokok were selected as two possible sites for marine facilities, given the development scenario derived under the Chapter III resource assessment (fig. V-1). There may be other potential marine facility sites. All potential sites would be analyzed in detail before final selection. Camden Bay and Pokok were selected because they are similar to Prudhoe Bay in having sufficient water depth seaward of the site so as not to require dredging. They also have open-ice periods similar to those at Prudhoe Bay (Arctic Environmental Information and Data Center, 1983). These sites were not selected on the basis of detailed engineering studies and the locations may prove less desirable after such studies are conducted, should the area be opened for development. However, Camden Bay and Pokok were used to assess environmental impacts under the various scenarios. ~

TRANSPORTATION OPTIONS FOR OIL AND GAS PRODUCTION

This section assesses the technology involved in the major elements of oil transportation methods. Pipelines are emphasized as the most reasonable transportation method because the TAPS is in place and operating. As production of the Prudhoe Bay oil field declines, TAPS should have adequate capacity to accommodate Arctic Refuge oil by the 1990's. However, if TAPS capacity (about 2.2 million barrels per day, according to W. Witten, Alyeska Pipeline Service Company, Jan. 9, 1986) were inadequate, capacity might be increased by looping or by improving pipeline hydraulics. The ultimate method to increase transmission capacity significantly is to construct a second pipeline parallel to TAPS between Prudhoe Bay and Valdez. Major elements of other systems are also described and evaluated. Gas transportation is considered separately, later in this chapter.

Because of the existence of TAPS, the most probable method is assumed to be transportation of crude oil produced on the 1002 area by pipeline to TAPS Pump Station 1, thence to the ice-free port of Valdez on the southern coast of Alaska.

Prior to TAPS, little was known about constructing oil pipelines in an arctic environment. Design and construction techniques used during TAPS construction (1974-77) and in the ensuing years of development of the Prudhoe Bay and Kuparuk River oil fields have advanced the state of the technology and have proved that hot-oil pipelines can be constructed, and reliably and safely operated.

Because of ice-rich permafrost conditions throughout the area, an elevated pipeline is the most probable system for transporting oil produced from the 1002 area west to TAPS Pump Station 1. To prevent thawing, elevated pipelines supported by VSM's placed into the frozen ground are most effective.

Experience from the operation and maintenance of TAPS has shown that unacceptable settling and stress in buried pipe may occur despite systematic geotechnical investigations. Even in soils thought to be thaw stable, ice may be present and go unnoticed during construction, and it may create problems in later years as the ice melts, causing differential settling in the pipelines.

The hot-oil, 24-inch pipeline from the Kuparuk River field to Pump Station 1 is entirely elevated on VSM's and support beams. A minimum 5-foot clearance is provided for caribou crossing; varying terrain features allow greater clearance in places. Also, caribou ramps (relatively short sections of gravel fill placed over the pipe) are provided. The Kuparuk River field pipeline support beams are constructed to carry more than one pipe.

A concept used in the Kuparuk River field pipeline, but not incorporated in TAPS, was construction of only one road for use as both a main transportation artery and a pipeline-maintenance road. A temporary ice road was used during construction of the pipeline, eliminating the need for a construction work pad. That construction placed the pipeline on the uphill side of the gravel road fill, enabling the road to act as a dam in the event of an oil spill. Cross drainage for water was provided by culverts, which could be quickly plugged if an oil spill occurred. Insofar as possible, a similar design could be proposed across level terrain in the 1002 area. Where the terrain is irregular, engineering and environmental constraints would require adjustments so the pipeline could be continued in a straight line but the road could follow the contours of the land.

Pipelines

Several alternative pipeline routes for transporting crude oil from the 1002 area to processing facilities were considered:

1. An elevated pipeline following an east-west inland route from the 1002 area, across State lands, to TAPS Pump Station 1.
2. An elevated east-west pipeline (onshore) from the 1002 area along the Beaufort Sea coast to TAPS Pump Station 1.
3. A marine pipeline east-west (offshore) along the Beaufort Sea coast to TAPS Pump Station 1. This pipeline would require north-south feeder lines from producing fields on the 1002 area to the coastal site.
4. An elevated east-west pipeline from the 1002 area across State lands to TAPS Pump Station 1, then a new pipeline paralleling TAPS to Valdez.
5. An inland pipeline from the 1002 area east to the Canadian border, thence southeastward through the Yukon and Northwest Territories, to connect with the existing oil pipeline systems in the Province of Alberta.

The most probable route for a pipeline was determined to be an inland route, which roughly bisects the 1002 area from east to west (fig. V-1) and is the route used for the assessment of environmental effects (Chapter VI of this report). The exact route would be determined primarily by the location of hydrocarbon discoveries; it would be adjusted to minimize impact to surface resources and to meet engineering requirements. The existing TAPS is believed to have the capacity to carry oil produced from the 1002 area by the earliest date production would start.

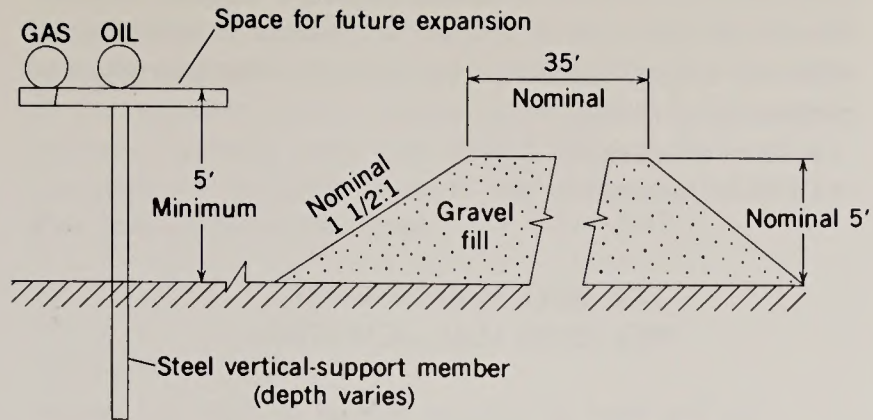


Figure IV-4.--Typical cross section of pipeline and road development. No scale.

Figure IV-4 shows a typical pipeline installation, in cross section. The pipeline could be designed like the Kuparuk River field pipeline, with support beams large enough to accommodate additional pipelines, depending on future needs for oil or gas, or possibly water. A road constructed on at least a 5-foot gravel fill would be needed to supply the oil-field facilities and give access for pipeline maintenance. Unless otherwise necessary for minimizing impacts on caribou migration or to accommodate engineering constraints, the pipeline could be built close to the upslope shoulder of the road to preclude an additional maintenance road. Access to valves, which require frequent maintenance, would probably call for a special work road connecting the valve site to the main road. In critical caribou habitat, the pipeline and main road might require separation. If so, a gravel maintenance work road might have to be constructed along the pipeline for segments where the pipeline and road are separated.

Figure IV-5 shows pipeline diameters required for various pumping rates. A pump station is required every 50 to 100 miles depending on desired pumping rate and topography. Therefore, two to three pump stations probably would be required for an inland route across the 1002 area. The first would be located near the oil field or fields and the second and third between the oil field(s) and Pump Station 1. Each pump station would contain pumping, oil-storage, power, pipeline equipment and repair, and communication facilities, living quarters for about 30 people, and environmental-support systems; the station would be constructed on a 7-acre (approximately) gravel pad. Other related facilities are described below (Mechanics Research, Inc., 1977).

SURGE AND STORAGE TANKS

Pipeline hydraulic design analyzes normal hydraulic gradients and the effects of pressure surges, which are controlled by means of suction and discharge relief protection at each pump station. Tanks at each station collect oil that is discharged through relief valves when surges occur; the collected oil is later returned to the pipeline.

Federal regulations (49 CFR 195.260) provide criteria for the locations and number of valves required for pipeline systems. For example, valves must be placed on each side of a water crossing more than 100 feet wide. A mainline valve system can be used to reduce the potential size of an oil spill. Valve locations are selected so that a spill at any point is limited to a predetermined maximum quantity (50,000 barrels on TAPS).

On TAPS, remotely operated gate valves close rapidly under emergency conditions to protect pump stations and environmentally sensitive areas. Check valves are used where the terrain slope allows the valve to effectively stop reverse oil flow and block potential oil spills.

COMMUNICATIONS

Maintaining continuous control of the pipeline from the Arctic Refuge to Prudhoe Bay would require a communication control system. The primary system could be a series of permanent microwave stations which link all pump stations, remotely controlled gate valves, and pipeline-maintenance centers with a control center. Each remote station typically includes a self-supporting steel antenna tower, two small buildings, 2 to 4 fuel tanks, a heliport, backup generators, and a battery system. Such stations, if patterned after TAPS, could be backed up by a satellite system and would be located on relatively high ground about 40 miles apart. Common-carrier circuits, telephone, and mobile radio systems would be incorporated into the overall pipeline communication system.

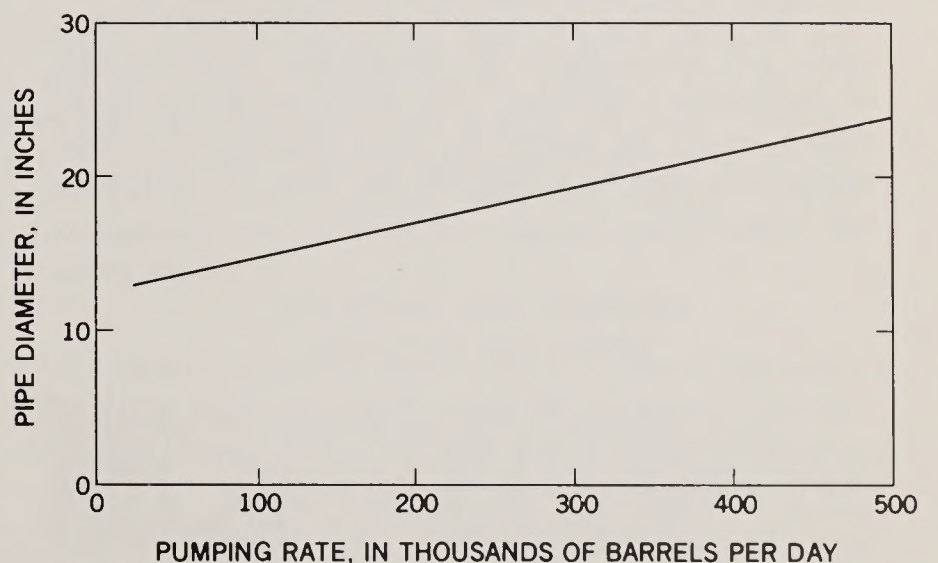


Figure IV-5.--Land-pipeline pipe diameter versus pumping rate. Modified from Han-Padron Associates (1985, fig. 7.2-1).

ROADS

As noted previously, a road would roughly parallel the pipeline across the 1002 area and continue across State lands to Pump Station 1. This permanent all-season gravel road would be built in accordance with accepted arctic engineering practices on 5-foot gravel fill, with a 35-foot-wide driving surface, and would support construction of the pipeline and link central production and marine facilities. The pipeline could be constructed during winter from a snow pad or ice road. If snow or water were not available in sufficient quantities, a gravel work road could be built. Gravel access roads would connect the main road to pump stations, valves, and maintenance stations. Emergency access to the pipeline during the summer would be accomplished by rolligon or similar vehicles. The availability of adequate gravel supplies on the 1002 area is uncertain. Gravel could be mined from inactive streambeds, but additional pits would have to be opened to obtain the large quantities required for roads, pump stations, airports, and maintenance-support facilities. Gravel might have to be mined from upland sites, river terraces, streambeds, lagoons, or other sites. Site selections would be based on environmental and engineering considerations as well as availability. No gravel would be removed from the active stream channels of major fish-bearing rivers or from barrier islands. All gravel removal would follow the guidelines for arctic and sub-arctic flood plains (Woodward Clyde Consultants, 1980a, b). Sites would be designed to provide fish and wildlife habitat after they are abandoned. For example, gravel-removal sites could be filled with water and provide areas for migratory-bird nesting and resting habitat, littoral zones for migratory bird and fish feeding, and deep water for fish overwintering. Thus, these gravel pits can also be potential water reservoirs. Bridges and culverts would be designed and constructed to provide cross drainage for roads in a manner that prevents erosion or adverse effects on the fisheries.

AIRFIELDS FOR CONSTRUCTION CAMPS

Airfields may be required at pipeline construction camps and pump stations or airstrips may be shared with oil development facilities. The typical airfield for these camps would be similar to those supporting airfield development, that is, 5,000-6,000 feet long, 150 feet wide, and 5 feet thick.

CONSTRUCTION CAMPS FOR ROADS AND PIPELINES

Camp buildings would be portable self-contained modules, equipped with functional furnishings for sleeping, eating, recreation, and with sanitation facilities. A typical camp houses 150-300 people. To minimize surface disturbance, these temporary camps should be located at the sites chosen for the permanent pump station. Production and transportation on the 1002 area would probably require two or three pump stations. Therefore, two or three camps would occupy the pump station sites;

two additional temporary camps might be required. These sites could be used for 2 years and would be rehabilitated when no longer needed or be used for road maintenance camps.

OIL-SPILL CONTINGENCY, INCLUDING LEAK DETECTION

The first lines of defense against oil spills are design and operational procedures (including personnel-training programs), properly designed and maintained equipment, adequate alarm systems, and strict adherence to industry and State and Federal government codes and regulations in construction and operation. It must be recognized, however, that even with the most comprehensive precautions, oil spills will occur. Operators of a pipeline across the 1002 area would be required to have an oil-spill contingency plan that, as a minimum, includes provisions for oil-spill control, which consist of (1) leak-detection systems; (2) methods for locating, confining, and cleaning up spills; (3) notification procedures for local, State, and Federal agencies; (4) corrective action for the affected area; (5) various types of oil-spill equipment; and (6) site-specific cleanup techniques.

A leak-detection system would include automatic instrumented detection systems and periodic ground and aerial surveillance. For best visual ground surveillance, either the all-season road or a gravel work road should be close to the pipeline. Aerial surveillance by helicopter or fixed-wing aircraft covers the greatest amount of area in the shortest time, but could be restricted by weather, hours of daylight, and wildlife considerations.

PIPELINE ROUTING

The 1002 area's widely diversified local environments require numerous engineering constraints regarding location and routing of pipelines, roads, and airstrips. This applies particularly to stream and ravine crossings where, to minimize environmental problems, cutbanks and braided streams must be avoided, especially by road crossings.

INLAND ROUTES

The southern part of the 1002 area provides more feasible stream crossings, relatively more stable soils, better drainage, and more sources of gravel than a route nearer the coastline. The actual availability of gravel is unknown, but at least 16 potential borrow pit sites located in active flood plains were identified by the Alaskan Arctic Gas Pipeline Company as possible sources of about 2.4 million cubic yards of sand and gravel for the ANGTS (Alaska Natural Gas Transportation System--U.S. Department of the Interior, 1976, "Alaska" volume, p. 10).

An inland pipeline from the 1002 area east into Canada was discussed in the TAPS and ANGTS reports (U.S. Department of the Interior, 1972, 1976). Construction of the pipeline would require a cooperative agreement between Canada and the United States, as well as Congressional authority to cross the designated wilderness area east of the Aichilik River.

COASTAL ROUTES

A coastline route would cross more ice-rich permafrost than an inland route (U.S. Department of the Interior, 1976, "Alaska" volume, p. 491). More of the route would be on thaw-unstable material; such material and the braided-stream crossings would complicate pipeline construction and could compromise pipeline integrity. A coastal route would have fewer stream crossings, but more of the route would be on active flood plains and cross wider delta areas. Work pads and roads in that flat, poorly drained area could result in water-ponding problems. Construction costs of an elevated oil pipeline would be expected to be slightly higher for a coastal onshore route than for an inland route because of (1) extra length, (2) higher gravel requirements, (3) poor drainage, and (4) poorer soils for construction. The earlier ANGTS study (U.S. Department of the Interior, 1972) for a buried natural gas line along coastal and inland routes also estimated slightly higher costs for the coastal onshore route.

SUBSEA MARINE ROUTES

For the past 15 years, the petroleum industry has been actively engaged in research and development of technology for the design and construction of subsea oil pipelines in the Arctic. Large-diameter marine-pipeline construction in the Beaufort Sea is considered to be technically feasible by some authorities (Han-Padron Associates, 1985). However, to date no marine pipelines have been constructed in the Arctic.

In general, the continental shelf of the Beaufort Sea of the Alaska coast is not more than 50 miles wide, and breaks at a water depth of 225 to 250 feet. The average duration of open-water conditions, during which a pipeline could be constructed, is approximately 50 days. A marine pipeline presents higher environmental risks than does an onshore pipeline. Wherever a hot-oil pipeline is buried in permafrost, differential settling is to be expected. Any significant settling could rupture the pipe, causing an oil spill. Repair and maintenance of a marine pipeline under ice would impose almost impossible engineering problems for much of the year.

Critical environmental factors affecting the design and construction of marine pipelines include ice and weather conditions, their effect on construction equipment and the

length of the construction season, the nature of the seabed soil, seabed ice scouring, and, in the permafrost zones, prevention of permafrost degradation. Marine-pipeline design, installation, and cost considerations are described below.

A major consideration in designing a marine pipeline for arctic waters is placement of the line with regard to ice and permafrost. Shorefast ice includes all types of ice, broken or unbroken, attached to the shore, beached, stranded, or attached to the bottom in shallow water. The fast-ice zone of the 1002 area extends from shore outward to water depths of approximately 10 to 66 feet. Intense interaction between moving pack ice and shorefast ice forms a shear zone of ice ridges, which often ground on the seabed. The keels of these ice pressure ridges and occasional pieces of ice islands scour deep gouges in the subsea floor during subsequent movement of the ice. Grounded ridges may extend outward to a depth of approximately 150 feet. From shore to 50-foot seabed depth, ice scour is frequent but relatively shallow. Scour is greatest at seabed depths of 65 to 100 feet. The deepest recorded scour is 18 feet at a seabed depth of 125 feet.

In nearshore areas, ice-bonded permafrost is probably present and must be considered in the design of an offshore pipeline (Heuer and others, 1983). But nearshore ice-wedge permafrost under shallow water, particularly along a rapidly receding coastline, is even more critical for design. A hot-oil pipeline placed in areas of ice-bonded or ice-wedge permafrost must be heavily insulated to limit thawing of permafrost. The best location for an offshore pipeline is at water depths of 6.5-65 feet, to minimize ice gouging. Beyond the 6.5-foot water depth the top of the ice-bonded permafrost generally is below the surface of the seabed. Inshore of the 18-foot bottom-depth contour, ice gouging is typically less than 1.6 feet (Mellor, 1978).

An arctic marine pipeline must be laid in a trench to ensure that the top of the pipe is below maximum ice-gouging depth. Several subsea trenching methods are available but have never been used in the Arctic. Because the construction season is short, fast-moving cutter-suction dredges or subsea plows would be required. Under development are self-propelled seabed plows, rippers, or cutting devices.

~ Maintenance and repair work on a marine pipeline in the Arctic would be difficult during the ice season (normally October through July). The only way to assure continuous operation is to have a loop line (a second pipeline parallel to the existing line) or similar built-in redundancy. ~

Marine pipelines must be waterproofed and weighed down with a concrete coating to give negative buoyancy. They also must be cathodically protected from corrosion by sea water, in accordance with industry standards.

Tankers

Transportation of petroleum products by icebreaker tanker in the Beaufort Sea has been considered for more than 15 years. However, no offshore loading terminals suitable for the area exist, nor do designs exist for icebreaker tankers, their support vessels, or loading terminals. Presumably, icebreaker tankers would transport crude oil to an ice-free transshipment terminal in the Aleutian Islands or on the Alaska Peninsula. Several other concepts have been considered, with or without internal storage capacity (Han-Padron Associates, 1985, p. 7-30). Greater knowledge of ice conditions and ice dynamics north of the Bering Strait is needed before the requirements and risks of operation in the Chukchi and Beaufort Seas can be adequately appraised.

A study on using submarine tankers, prepared by a team headed by the Newport News Shipbuilding and Drydock Company (NNSDC, 1975) for the U.S. Marine Administration, was updated by Han-Padron Associates (1985, p. 7-53). Han-Padron escalated the capital and operating costs to compare transportation costs for submarine tankers with those for icebreaker surface tankers. A submarine tanker designed to operate under the Arctic icepack is limited as to propulsion methods and overall size. Current technology limits the power source to a nuclear reactor, although fuel-cell powerplants might propel smaller submarines. The original study (NNSDC, 1975) indicated that no existing shipyard could construct or maintain a submarine of sufficient size (200,000-300,000 tons deadweight) to be efficient in such an operation. The updated study suggests that the unit-transportation cost of a submarine tanker would not differ significantly from that provided by an icebreaker tanker of similar capacity. Technical problems associated with loading, construction, and operation have yet to be solved.

Other Transportation Methods

Several other transportation systems have been proposed and discussed in detail (U.S. Department of the Interior, 1972, 1976). Only a few are discussed here, as none is a realistic alternative to a pipeline in terms of safety, economics, and environmental impact. The reader should refer to the cited reports for further information.

Two rail routes have been considered for transporting North Slope oil. The shorter, in terms of new railroad construction, is an extension of the Alaska Railroad. This railroad is State-owned and has 470 miles of track from Seward to Fairbanks. The extension would be northward across the Yukon River and the Brooks Range to the North Slope oil fields near Prudhoe Bay. The other route crosses Alaska and Canada from Prudhoe Bay to Whitefish, Montana, via Dawson, Yukon Territory. Either route would encounter major construction constraints and operational problems in accommodating, handling, loading and unloading, marshaling trains, and maintaining track and

rolling stock. Potential environmental impacts are air and noise pollution, oil spills, and degradation of fish and wildlife habitat caused by roadbed construction through mountainous terrain.

Possible, but not practical, is operating a large fleet of trucks to haul oil to a southern Alaska port, for transshipment to West Coast ports, or to the north-central United States via a trans-Alaska-Canada route. High operating costs, air and noise pollution, and the high potential for oil spillage make truck transport impractical. The existing TAPS haul road (Dalton Highway) would not be adequate for such high-volume traffic, which would require almost bumper-to-bumper trucks.

Natural Gas Transportation System

Since the early 1970's, industry has given serious consideration to developing a transportation system to deliver Alaskan North Slope (ANS) natural gas to the market place. Gas produced at Prudhoe Bay is currently used on-site for power generation, enhanced oil recovery, or is reinjected, inasmuch as it is not yet economical to produce for marketing.

In December 1981, the Secretary of the Interior issued a right-of-way to the Northwest Alaska Pipeline Company to construct a large-diameter, chilled, buried gas pipeline and related facilities from Prudhoe Bay to domestic markets in the lower-48 States. However, by 1985 the project sponsors had reduced their efforts to complete the Alaska Arctic Gas Pipeline until market conditions for ANS natural gas improved. A timeframe for remobilizing the project has not been identified.

~ In 1986, the Yukon Pacific Corporation (YPC) amended its application to the BLM for Federal permits to construct and operate a buried gas pipeline from Prudhoe Bay to a tidewater liquid natural gas (LNG) terminal at Valdez. That pipeline project, called the Trans-Alaska Gas System (TAGS), would export ANS natural gas to markets in Pacific Rim nations, such as Japan and Korea. Export of Alaska North Slope natural gas outside the United States would require approval of the President of the United States, pursuant to the Alaska Natural Gas Transportation Act of 1976. ~

Accordingly, it is likely that a gas delivery system from Prudhoe Bay would provide ready market access for any gas discovered in the 1002 area, should it become economically recoverable.

The environmental impact statement for the Alaska Arctic Gas Pipeline project (U.S. Department of the Interior, 1976) described the overall effects that would result from construction and operation of a gas pipeline transportation system through the Arctic National Wildlife Refuge. This pipeline system proposed construction of a buried, chilled

gas pipeline through the coastal plain of the Arctic Refuge to the Canadian border, to facilitate production of gas from the Mackenzie Delta region of Canada. However, for purposes of this report, it is presumed that commercial quantities of natural gas discovered in the 1002 area would be processed and transported west to Prudhoe Bay using facilities shared with oil development and transportation on the 1002 area. Ideally, the vertical support members for the oil delivery system to TAPS could be designed so that construction, operation, and maintenance of both oil and gas systems could be collocated. It is also assumed that gas production and transportation systems would not be constructed until a natural gas transportation system was operational between Prudhoe Bay and markets outside Alaska, now speculated not to occur before the middle to late 1990's.

Construction of an oil transportation system from the Arctic Refuge would have a higher priority than a gas transportation system due to the anticipated decline in oil from Prudhoe Bay which would make available oil capacity in the TAPS during the late 1990's. Therefore, construction of the oil and natural gas transportation systems would be sequential on the Arctic Refuge. The timing for the natural gas transportation system would depend upon the final design and delivery capability of the gas pipeline system south from Prudhoe Bay, combined with the consideration of economic factors in both domestic U.S. and foreign natural gas markets.

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RIPARIAN HABITAT

CHAPTER V

ALTERNATIVES

~ INTRODUCTION ~

This chapter identifies and evaluates five alternatives which are considered to be representative of the full spectrum of possible actions that could be taken with respect to a decision to open the 1002 area to oil and gas exploration and development.

- Alternative A: Full Leasing
- Alternative B: Limited Leasing
- Alternative C: Further Exploration
- Alternative D: No Action
- Alternative E: Wilderness Designation

These five options are all technically and economically feasible. They are distinctly different from each other and lend themselves to independent analysis, thus permitting concentration on those issues that are truly significant to the decision to be made. Comparisons of the effects of each alternative are provided at the conclusion of the assessments in Chapter VI.

ALTERNATIVE A--FULL LEASING OF THE 1002 AREA

~ Under the alternative of full leasing, it is assumed that Congressional action would allow all Federal subsurface ownerships of the 1002 area to be available for development through a leasing program administered by the Department of the Interior. This action would also open to oil and gas development and production the private lands within the refuge. This is the preferred alternative, as more fully discussed in Chapter VIII, the Secretary's recommendation. The exact terms of the leasing program would be developed in response to specific legislation passed by the Congress, and in consideration of the recommendation of the Secretary of the Interior. ~

Presumably, major portions of the 1002 area would be leased and additional geophysical exploratory work would take place on all leased areas before exploration wells are drilled. Leaseholders would likely focus first on those areas and geologic structures believed to have the highest probability of containing commercial quantities of oil. It is feasible for phased development to occur.

The 1002 area contains a combination of identified potential petroleum prospects having a mean conditional estimated total of 3.2 billion barrels of economically recoverable oil under current and foreseeable economic conditions (Chapter III). These prospects are grouped into 4 geographic areas (blocks) of the 1002 area to facilitate an analysis of the effects of oil development on the environment. The four blocks are depicted in Chapter III (fig. III-14).

Alternative A assumes that:

1. Although both oil and gas would be leased, initially only oil will be developed and transported to market. Associated gas will be reinjected and/or used for field operations in a manner similar to other North Slope fields, until gas production becomes economical and adequate markets are identified.
2. ~ Development would be sequential on the area, and oil production will start about the year 2000. ~
3. Development will be unitized within the 1002 area and on privately owned subsurface resources.
4. A single trunk oil pipeline will transport oil from Federal leases and from any private lands in the 1002 area to Pump Station 1 of the Trans-Alaska Pipeline System (TAPS).
5. Development, production, and transportation of oil from the 1002 area are considered to be independent of any offshore production; however, production infrastructure could be shared.
6. The State of Alaska will allow a trunk oil pipeline to cross State lands between the western boundary of the 1002 area and TAPS Pump Station 1 at Prudhoe Bay (a distance of about 50 miles).
7. Once the Congress approves leasing, but prior to lease sales, industry will be allowed to conduct additional geophysical and surface geological exploration work.

~ According to the size, number, and characteristics of prospects described in Chapter III, and the production and transportation scenarios described in Chapter IV, the number and types of facilities likely to be required for development and production of oil resources in the 1002 area are listed in table V-1. For the sake of maintaining data confidentiality, figure V-1 shows a highly generalized placement of production and transportation facilities based on typical North Slope prospect characteristics for three localities within the 1002 area. This assumes successful exploration in all three localities. ~

Actual placement of oil production facilities and marine facilities on the 1002 area, or location of the trunk pipeline from producing fields to TAPS Pump Station 1, depends upon site-specific geotechnical, engineering, environmental, and economic data that can be determined

only after a specific prospect has been drilled, and a discovery made and confirmed.

Chapter IV describes the types and numbers of facilities that might be necessary for oil production in the 1002 area. Typically, these include for each developed prospect: central production facility (CPF) and initial pump station for the oil pipeline, all-weather airfield, consolidated production and reinjection well pads, and an internal network of roads and gathering lines connecting pads and the CPF. A trunk oil pipeline would connect the CPF to Pump Station 1. From Pump Station 1, oil from the 1002 area would move through the existing TAPS to Valdez and then by tanker to market. Depending on the amount of final through-put, one or several additional pump stations may be required.

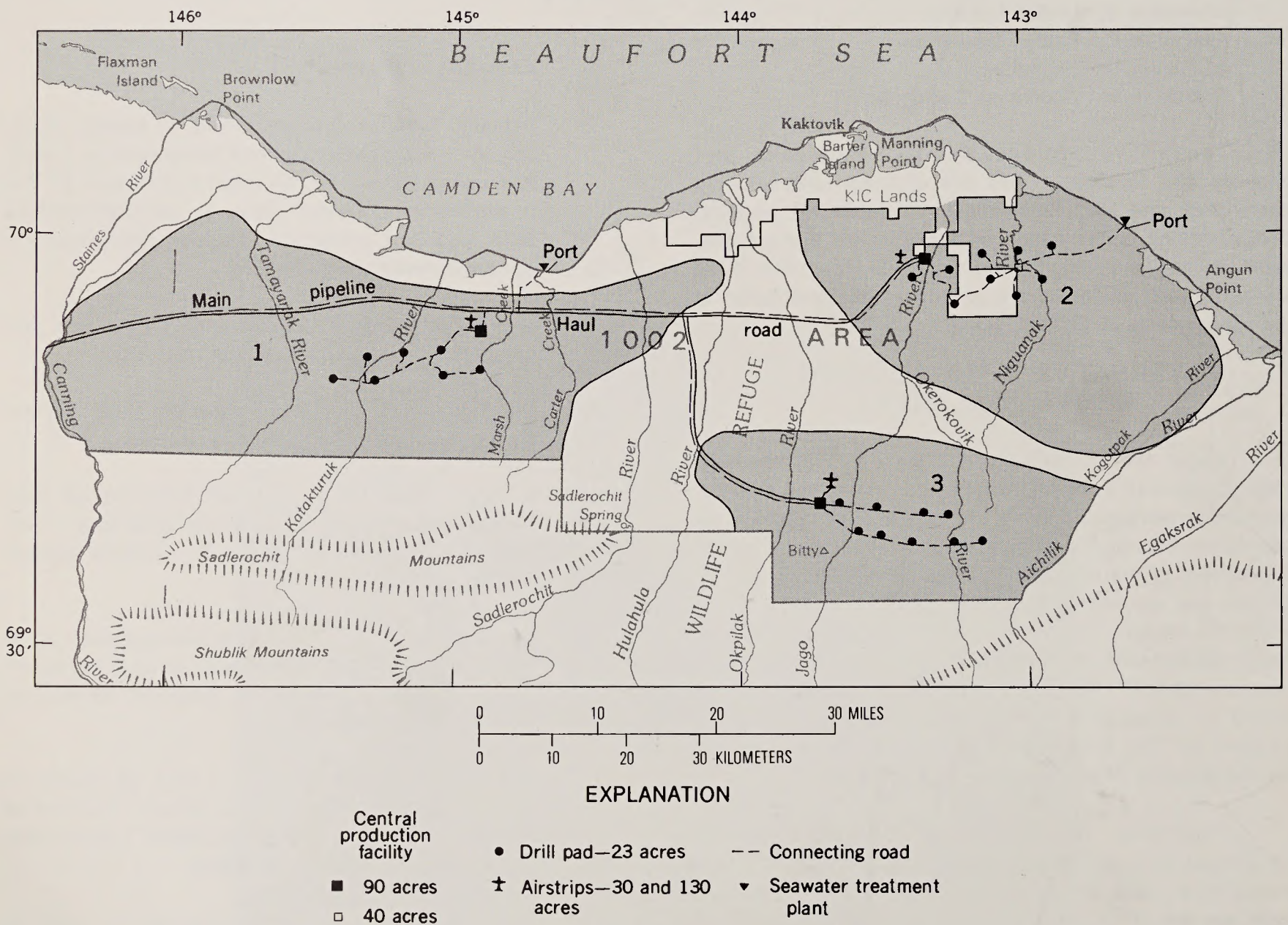
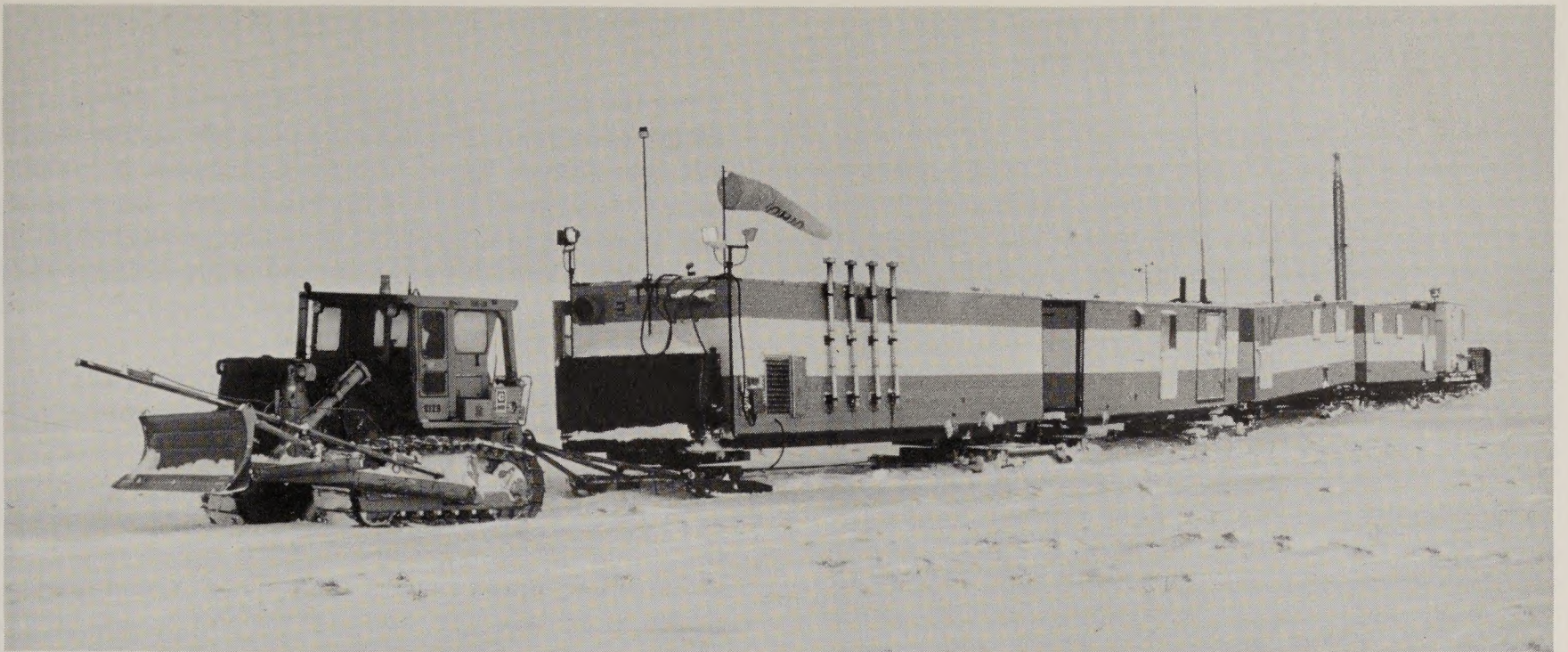


Figure V-1.—Hypothetical generalized development of three major prospects within the 1002 area under full leasing if economic quantities of oil are discovered. Numbers indicate three localities (shaded) having typical prospect characteristics.



"CAT TRAIN" FOR SEISMIC EXPLORATION

Table V-1.--Number and area of in-place oil-related facilities assumed to be associated with ultimate development of estimated mean conditional recoverable oil resources made available by full leasing or limited leasing of the 1002 area. [mi, miles; cu yds, cubic yards; ac, acres]

Facility	Approximate units ¹	
	Full leasing	Limited leasing
Main oil pipeline within the 1002 area ²	100 mi (610 ac)	80 mi (490 ac)
Main road paralleling main pipeline and from marine facilities ²	120 mi (730 ac)	100 mi (610 ac)
Spur roads with collecting lines within production fields	160 mi (980 ac)	120 mi (730 ac)
Marine and salt-water-treatment facilities	2 (200 ac)	2 (200 ac)
Large central production facilities	7 (630 ac)	6 (540 ac)
Small central production facilities	4 (160 ac)	3 (120 ac)
Large permanent airfields	2 (260 ac)	2 (260 ac)
Small permanent airfields	2 (60 ac)	1 (30 ac)
Permanent drilling pads	50-60 (1,200-1,600 ac)	30-40 (700-1,000 ac)
Borrow sites	10-15 (500-750 ac)	8-13 (400-650 ac)
Gravel for construction, operation, and maintenance.....	40 million- 50 million cu yds	35 million- 40 million cu yds
Major river or stream crossings.....	Maximum 25	Maximum 15

¹Figures given in miles refer to linear miles of the facilities. Areas were calculated on the basis of 50-foot widths each for the main oil pipeline and main road, totaling a 100-foot right-of-way for the main transportation corridor. A 50-foot right-of-way was assumed for spur roads with collecting lines. The numbers of nonlinear units are also provided.

²The distance from the 1002 western boundary to TAPS Pump Station 1 is approximately 50 miles, across State of Alaska land. This 50 miles is not included in the mileage estimates.

~ ALTERNATIVE B--LIMITED LEASING
OF THE 1002 AREA ~

This alternative discusses a leasing program that would develop if the Congress chose to pass legislation, based on environmental considerations, that would limit the amount of the 1002 area available for leasing. There would be no leasing, exploration, development, or transportation of oil from or through that portion of the Porcupine caribou herd (PCH) concentrated calving area (as defined in Chapter II) which has been most frequently used (fig. II-5; pl. 2A). The exact size of this area would be equal to the area used for concentrated calving in approximately 50 percent of the years for which calving data are available, at the time legislation is passed. This could eliminate all or part of Block D from leasing, based on at least 7 years of most frequent concentrated use in the 15 years for which data are currently available (pl. 2A). The remainder of the 1002 area would be offered for leasing; presumably, all potentially economic prospects would be leased, explored, and developed.

The assumptions in this alternative are the same as for full leasing, including the opening of the Kaktovik Inupiat Corporation/Arctic Slope Regional Corporation (KIC/ASRC) lands. Approximately 2.4 billion barrels (800 million barrels less than in Alternative A) of economically recoverable oil are estimated as the mean conditional resource which might be available for development under this alternative.

A highly generalized placement of production and transportation facilities under the limited leasing alternative is shown on figure V-2.

Production and transportation facilities were described in the full leasing alternative. Under limited leasing, no infrastructure would be extended into the southeastern portion of the 1002 area, based on the area most frequently used for concentrated calving, as described above. All other facility requirements would be virtually the same (table V-1).

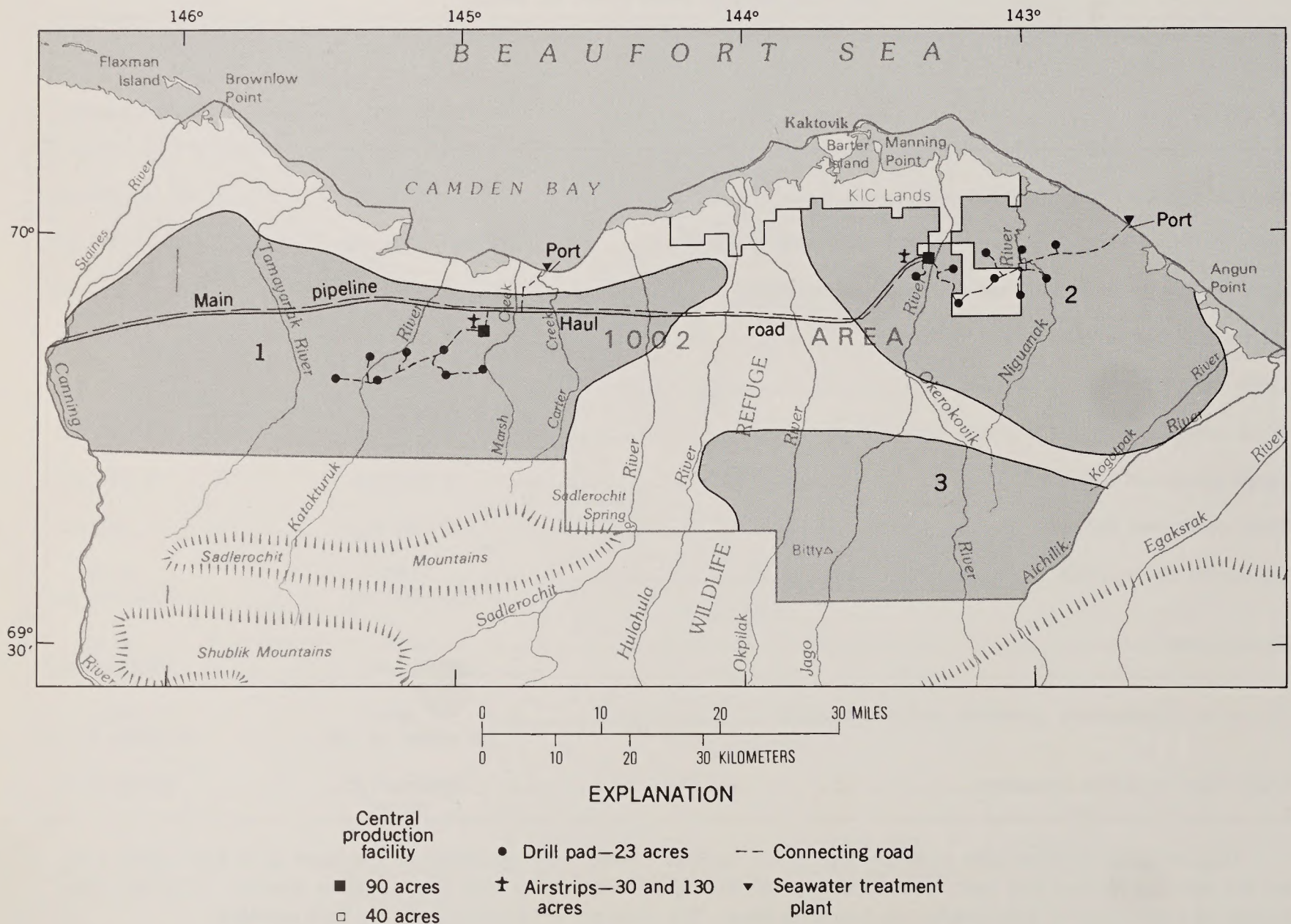


Figure V-2.--Hypothetical generalized development of two major prospects within the 1002 area under limited leasing if economic quantities of oil are discovered. Numbers indicate three localities (shaded) having typical prospect characteristics.

ALTERNATIVE C--FURTHER EXPLORATION

Under this alternative, the Secretary would recommend additional exploration, including exploratory drilling, to permit acquisition of more data to aid the Secretary and the Congress in their decision of whether or not to authorize leasing of the 1002 area. Acquisition of additional data could be by the Government, or industry, or both.

Section 1002 of ANILCA (Alaska National Interest Lands Conservation Act of 1980) has afforded the Department of the Interior the opportunity to acquire a substantial amount of exploration data in the 1002 area. During two winter field seasons, private industry obtained more than 1,300 line miles of seismic data on a 3x6-mile seismic grid over a large part of the 1002 area. A substantial amount of gravity, magnetic, geochemical, paleontological, and shallow stratigraphic data was also collected. The Bureau of Land Management and Geological Survey acquired additional data through in-house research and field investigations over several field seasons.

Analysis of the available geological and geophysical data has revealed that the 1002 area is a very complex geological terrane, and additional geological and geophysical data might provide a basis for a better defined assessment of its oil and gas potential. Additional seismic data could better define some of the more complex geologic structures that have been identified. It is expected that if a decision is made to allow leasing of the 1002 area, industry would want to obtain more detailed seismic data over particular areas of interest in order to make a more accurate determination of oil and gas potential prior to a lease sale. These data would also be made available to the Department for its use in determining the fair market value of tracts to be leased.

The location and size of geologic structures have been generally defined. However, the nature of the rocks present remains virtually unknown owing to a lack of deep stratigraphic, paleontological, and geochemical data specific to the 1002 area. Therefore, only indirect inferences based on surface and near-surface geological data and on well data from outside the 1002 area can be made as to the nature of source and reservoir rocks and the type of hydrocarbon present. A program to drill off-structure test wells would provide subsurface geological information on the 1002 area and eliminate some of the uncertainties in the oil and gas assessment such as the probability of the occurrence of adequate source and reservoir rocks, and also the probable mix of hydrocarbons. This type of information might better define the more prospective parts of the 1002 area that should be considered for leasing.

Four deep test wells could be drilled off-structure similar to the stratigraphic test wells (COST wells) drilled in the Outer Continental Shelf. These wells would provide more definitive data on the stratigraphy, paleontology,



geophysics, and geochemistry of the rock formations. Core samples would be taken to determine the quality of the source rocks, the characteristics of the reservoir rocks, and the availability of seals to trap hydrocarbons. Possible locations for stratigraphic test wells are:

1. East of the Canning River in the northwest block (Block A, fig. III-1) to test primarily for geologic conditions similar to those of the Prudhoe Bay field.
2. Near the Hulahula River (Block B, fig. III-1) between the Marsh Creek anticline to the west and larger mapped geologic structures to the east (Block C, fig. III-1).
3. In the northeastern part of the 1002 area north of the large mapped geologic structure and south of the KIC lands (Block C, fig. III-1).
4. Near the large mapped geologic structures in the southern foothills (Block D, fig. III-1).

ALTERNATIVE D--NO ACTION

This alternative describes the probable future management of the 1002 area if the Congress chose to take no further legislative action regarding the 1002 area of the Arctic Refuge. According to the provisions of sections 1002 and 1003 of ANILCA, an act of the Congress would be prerequisite to leasing or other development leading to oil and gas production on the Arctic Refuge. If the Congress chose instead to designate all or part of the 1002 area as wilderness, that too would take legislative action. If, instead, the Congress chose to allow the management of the 1002 area to continue under existing legal authorities guided by the Arctic Refuge comprehensive conservation plan (CCP) outlined by section 304(g) of ANILCA, no additional Congressional action would be required.

The management goals of the Arctic National Wildlife Refuge, until further defined by the CCP, are to maintain the existing availability and quality of refuge habitats with natural forces governing fluctuations in fish and wildlife populations and habitat change; to provide the opportunity for continued subsistence harvest of natural resources by local residents in a manner consistent with sound natural resource management; and to provide recreational and economic opportunities compatible with the purposes for which the refuge was established.

Section 304(g) of ANILCA mandates that management of the 16 National Wildlife Refuges in Alaska, including the Arctic Refuge, be assessed through the CCP. This requires that the plan: (1) designate areas within the refuge according to their respective resources and values; (2) specify the programs proposed for conserving fish and wildlife and maintaining the values for which the refuge was established; and (3) specify uses which may be compatible with the major purposes of the refuge. The preferred alternatives identified in this process would establish the long-term basic management direction for each refuge. This planning allows for the evaluation of a range of alternatives for refuge management and consultation with the appropriate State agencies and Native Corporations. The Fish and Wildlife Service (FWS) is using the environmental impact statement (EIS) process to implement the CCP's. Following a series of public hearings and comments on a draft EIS, a preferred alternative would be chosen by the Alaska FWS Regional Director, described in a final EIS, and documented by a Record of Decision.

Currently, the CCP for the Arctic Refuge is in the first or review and data-collection phase and calls for completion of the CCP by the spring of 1988. The 1002 area has been omitted from this planning, pending the decision of the Congress as to its future management. If this no-action alternative were selected by the Congress, the 1002 area would be added to the CCP as an integral part of the Arctic Refuge. Depending on the stage of

planning, at least the CCP, and perhaps some step-down management plans, would need to be amended or supplemented to include management of the 1002 area.

Under section 1008 of ANILCA, a policy was established to permit certain oil and gas activities, including leasing and development, on Alaska refuges in areas where such activities are deemed to be compatible with the major purposes for which a particular refuge was established. Because of the provisions of sections 1002 and 1003, section 1008 does not apply to any part of the Arctic Refuge. Selection of Alternative D would preclude production of oil and gas from the Arctic Refuge, and leasing or other developments leading to oil and gas products.

Step-down management plans for the Arctic Refuge would be developed for specific activities once the CCP was completed. These management plans might address activities such as public use, wildlife inventories and other scientific research, wild and scenic rivers, wilderness management, and fire management. Harvest of fish and wildlife would generally be conducted in accordance with the State of Alaska Department of Fish and Game regulations, and subsistence use of the refuge would continue.

The Arctic Refuge would be managed under the legal authorities found in ANILCA and the National Wildlife Refuge System Administration Act of 1966 (Public Law 89-669). Other laws and their amendments that affect the management of the 1002 area and the Arctic Refuge in general include but are not limited to the Migratory Bird Treaty Act, Endangered Species Act, Antiquities Act, Clean Air Act, Clean Water Act, Coastal Zone Management Act, Fish and Wildlife Act of 1956, Marine Mammal Protection Act, National Environmental Policy Act, National Historic Preservation Act, Refuge Recreation Act, Refuge Revenue Sharing Act, and the State of Alaska Fish and Game Regulations. Provisions of the Wilderness Act would apply to those 8 million acres of the Arctic Refuge outside the 1002 area.

Under Alternative D, activities proposed for the 1002 area would be subject to a compatibility determination as required by ANILCA section 304(b) and the Refuge Administration Act, as is the case for the remainder of the Arctic Refuge. Permissible activities could include hunting, fishing, subsistence harvest, river trips, hiking, photography, and certain other forms of recreation and compatible scientific research. Guiding for recreational activities, trapping, and other commercial activities determined to be compatible with refuge purposes also would be allowed. These commercial activities could conceivably include activities as diverse as onshore support and transportation facilities for offshore oil and gas drilling and production. Any proposed activity would be reviewed for compatibility before it could be permitted. Because compatibility determinations are site-specific, and the list of probable

activities is long and speculative, effects of specific activities are not assessed in Chapter VI.

The establishment of aids to navigation and facilities for national defense would be authorized under ANILCA section 1310. Weather, climate, and research facilities could also be permitted.

Title XI of ANILCA governs access on Federal lands in Alaska. Authorized forms of access on the Arctic Refuge include snowmachines during periods of adequate snow cover, aircraft, motorboats, and other means if found compatible.

Refuge management could include activities such as wildlife surveys, reintroduction of native fish and wildlife species, fisheries management, prescribed burning for habitat enhancement, and construction of public facilities where appropriate. Although these activities are allowed by law, their actual implementation and the extent of implementation would be decided through the CCP and subsequent management plans.

Other energy alternatives, including energy conservation, would have to be pursued to compensate for the opportunity for production of oil and gas from the 1002 area which would be forgone if Alternative D was implemented.

ALTERNATIVE E--WILDERNESS DESIGNATION

Under this alternative, the Congress would designate the 1.55-million-acre 1002 area as wilderness, within the meaning of the 1964 Wilderness Act (Public Law 88-577).

No further study or public review is necessary for the Congress to designate the 1002 area as wilderness. Previous studies and public debate have sufficiently covered the issue. A wilderness review of the Arctic Refuge was conducted in the early 1970's pursuant to the provisions of the Wilderness Act. A draft report was prepared in 1973; however, the draft was never made final nor was public comment obtained.

The issue of wilderness designation for all the Arctic Refuge, including the 1002 area, was debated extensively by the Congress and the public in widely held hearings from 1976 through 1980 during the development and passage of ANILCA (Eastin, 1984). The House of Representatives generally favored designation of the 1002 area as wilderness, whereas the Senate generally did not. The Senate view was that designating the area as wilderness was premature until a resource assessment of the oil and gas potential was completed and reviewed by the Congress. The Senate view prevailed and became section 1002 of Title X of ANILCA.

The draft report resulting from the original wilderness study recommended that the original 8.9 million acres of the Arctic Refuge be designated as wilderness, with the exception of 74,516 acres consisting of tracts at Camden Bay (456 acres), Beaufort Lagoon (420 acres), Demarcation Point (10 acres), Lake Peters (10 acres), the village of Kaktovik (141 acres), the military withdrawal on Barter Island (4,359 acres), and land in the vicinity of Barter Island that was to be selected by the KIC under the Alaska Native Claims Settlement Act (ANCSA) (69,120 acres). Section 702(3) of ANILCA ultimately designated approximately 8 million acres of wilderness on the Arctic Refuge which encompassed all the pre-ANILCA refuge with the exception of the 1002 area.

This alternative would result in wilderness designation of the entire 1.55-million-acre 1002 area, except for the abandoned DEW line sites at Beaufort Lagoon and Camden Bay, native allotments, and land owned by the KIC. The 1002 area would still be included in the CCP, as described in Alternative D, but would be managed as wilderness under the provisions of the Wilderness Act, the National Wildlife Refuge System Administration Act, and ANILCA.

Permitted uses in wilderness include hunting, fishing, backpacking, river trips, and photography. Commercial activity would be restricted to commercial guiding for such activities. These activities may be restricted or eliminated if necessary in designated wilderness areas under the provisions of other laws or regulations. Motorized equipment would generally be prohibited. Wilderness designation would not affect the air space over the area. The use of motorboats and snowmachines (during periods of adequate snow cover) would be authorized for traditional activities--for example, subsistence harvest or access to inholdings such as native allotments. Cabins could be constructed in wilderness areas if they were necessary for subsistence trapping, public safety, or administration of the area.

In contrast to the "no-action" alternative, use of motorized equipment by the FWS in administering the area would only be allowed consistent with the minimum-tool concept. (Minimum-tool concept is use of the minimum action or instrument necessary to successfully, safely, and economically accomplish wilderness management objectives.) Situations for which motorized access might be used include emergencies involving public health or safety and search-and-rescue operations. Landing of aircraft would be permitted. Other government agencies (local, State, Federal) would be allowed to use motorized equipment in carrying out legitimate activities in wilderness consistent with the minimum-tool concept. An example would be the use of helicopters by the Department of the Interior to carry out the ANILCA section 1010 Alaska Mineral Resource Assessment Program (AMRAP). Management activities such as wildlife control, prescribed burning, habitat rehabilitation, predator control, reintroduction of native fish and wildlife species, and wildlife surveys would be permissible, though not necessarily practiced, in the

designated wilderness area. The appropriateness of these activities would be addressed in the CCP.

As in the "no-action" alternative, placement and maintenance of navigation aids, communication sites and related facilities, and facilities for national defense could be permitted (ANILCA section 1310), as could facilities for weather, climate, and fisheries research.

Other energy alternatives, including energy conservation, would have to be pursued to compensate for the opportunity for production of oil and gas from the 1002 area which would be forgone if Alternative E was implemented.

REFERENCE CITED

Eastin, K. E. 1984, Wilderness review for Arctic National Wildlife Refuge's 1002 area: U.S. Department of the Interior, Office of the Solicitor, 21 p.



CHAPTER VI

ENVIRONMENTAL CONSEQUENCES

~ INTRODUCTION ~

This chapter analyzes and discusses the potential environmental effects of activities that could occur from implementing the alternatives described in Chapter V:

Alternative A: Full Leasing

Alternative B: Limited Leasing

Alternative C: Further Exploration

Alternative D: No Action

Alternative E: Wilderness Designation.

The impacts of Alternatives A through E are summarized and compared at the end of this chapter.

Development, if it occurs, may differ somewhat from the scenarios assessed here. The analysis of oil development is based on best available information as to possible location and size of the prospects delineated by the seismic surveys (fig. III-1). Additional exploration would further refine these data. Oil and gas may be discovered in other parts of the 1002 area or the areas now delineated may be nonproductive. The magnitude and types of effects resulting from development should be essentially the same for all development scenarios. If oil is not present in economically recoverable quantities, then the environmental effects of Alternatives A and B would be reduced, possibly to those described for Alternative C.

This programmatic legislative environmental impact statement (LEIS) discusses the overall oil and gas development programs which might occur on the 1002 area. Without site-specific information, precise effects cannot be predicted. If the area is opened to leasing, this programmatic LEIS could suffice for the initial lease sale if the Congress so stated in the enabling legislation. However, environmental effects would be reassessed at all appropriate stages for each subsequent lease sale and all development stages, as the required authorizations are obtained.

The environmental effects described in this chapter are based on scenarios developed for the mean estimated recoverable resource of 3.2 billion barrels of oil. There is a 5-percent chance that more than 9.2 billion barrels of oil could be recovered. The environmental effects associated

with this 5-percent case would likely result from the extended development of 2 or 3 of the largest prospects if they contain a much larger volume of oil than expected. The effects would not increase proportionally with increased production.

Based on development of the oil field at Prudhoe Bay, well spacing for prospect(s) contributing to the 9.2-billion-barrel case would be assumed to be the same as that for the 3.2-billion-barrel case. For either case, field life would be about 30 years. Most additional surface impacts would be due to expansion and modification of the infrastructure used to develop the individual oil fields. This could mean construction of additional drilling and production pads, additional production facilities, and connecting lines. These facilities will still be concentrated within the boundaries of a field, so impacts would be largely confined to the same surface area as assessed at the 3.2-billion-barrel mean recoverable case, although they would modify some additional acreage.

The additional production from the 5-percent case is not likely to significantly change the impacts of a main oil pipeline, haul road, airstrips, ports, and supporting roads and infrastructure from that required to develop the 3.2-billion-barrel case. A larger diameter oil pipeline could be used to accommodate increased oil production. Additional disturbance and displacement of wildlife might occur as a result of more intense activities and increased or prolonged traffic on the roads and at the ports. The roads and port facilities anticipated for the mean case development should be capable of handling that increased traffic.

Whether or not the development of potential gas resources becomes economic, gas development and the infrastructures to support it would be expected to share oil development and transportation facilities. Therefore, no appreciable increase in the intensity of environmental impacts is anticipated, although the life of a field may be extended by gas production. Development of gas would require separate administrative approval and would be subject to appropriate environmental review prior to such approval.

~ Developing the Assessment ~

To determine the potential environmental consequences of the various alternatives, a Fish and Wildlife Service (FWS) environmental assessment team of biologists, formed in February 1985, met with Bureau of Land Management (BLM) and Geological Survey (GS) scientists to determine the extent and probable surface modifications required for oil development on the 1002 area. Maps of fish and wildlife use areas (pls. 1-3) were overlaid with full and limited development scenarios (figs. V-1 and V-2), allowing measurement of direct habitat loss or alteration. The nature and magnitude of direct and indirect habitat losses, disturbance, mortality, and other potential effects were then determined. Effects are characterized as major, moderate, minor, or negligible (table VI-1) for the physical, biological, and human environments of the 1002 area that would be affected. Effects that could likely persist at least as long as the field life were considered "long-term" and those likely to persist less than the field life (30 years; see Chapter IV) were considered "short-term."

The scenarios for development in Alternatives A and B depict hypothetical infrastructures based on a projected hydrocarbon potential at the mean economically recoverable resource estimate. If the 5-percent-probability production occurs, the effects remain basically the same, as explained earlier.

Leasing and development, from field exploration through oil production, transportation, rehabilitation, and abandonment, would be sequential on the 1002 area. For purposes of impact assessment, it was assumed that Blocks A, C, and D (for Alternative A) were leased and that exploration was successful. It was further assumed that each of these blocks, plus Block B which would be crossed by the main pipeline, would at some point in time concurrently have some phase of activity occurring in them, whether it be winter seismic investigations; exploration well drilling; construction of airstrips, port developments, pipelines; rehabilitation; and so forth. If some of the currently prospective areas contain no economically recoverable oil (of which there is an 81-percent chance), then predicted impacts would be substantially less, probably limited to those associated only with exploratory well drilling and cleanup as described under Alternative C. This decrease in adverse effects would be particularly true if delineated prospects in Blocks C and D produced "dry holes"; not only would development of the fields not occur, but the main pipeline could be shortened by a significant amount, and the Pokok port site would be unnecessary. Such speculation, however, precludes meaningful analysis.

Until a leasing program is actually developed for the area and exploration occurs, it would be speculative as to which tracts would be leased first, which areas would prove to contain economically recoverable oil, and which areas would be the first developed. This uncertainty is compounded by the existence of the Kaktovik Inupiat

Corporation/Arctic Slope Regional Corporation (KIC/ASRC) lands which would be available for oil and gas development, production, and transportation, should the Congress choose to open the 1002 area. An exploration well has already been drilled on the KIC/ASRC lands but all well data have been held confidential. If hydrocarbon resources are present, development, production, and transportation would (1) be expected to proceed on a much more rapid schedule, absent the need for a lease sale, and (2) be expected to influence leasing and development patterns on the 1002 area itself. This could influence construction of a pipeline system as well, should any reserves be found in the KIC/ASRC lands that could, as a single "stand-alone" prospect, support the cost of a transportation system to the Trans-Alaska Pipeline System (TAPS) for produced oil.

Therefore, as required by the Council on Environmental Quality (CEQ) regulations (40 CFR 1502.22), oil-related activities reasonably foreseeable at some point in time throughout the 1002 area were evaluated for the purposes of impact assessment.

Experiences at Prudhoe Bay and surrounding oil fields, and on the National Petroleum Reserve in Alaska (NPR), have provided much valuable information which assisted in many of the analyses and conclusions in this report. As further required by the CEQ's regulatory amendments (40 CFR 1502.22(b)(3) and (4)), this chapter summarizes existing credible scientific evidence relevant to evaluating reasonably foreseeable significant adverse impacts, based upon theoretical approaches or research methods generally accepted in the scientific community. There is substantial uncertainty about the ability of wildlife in the 1002 area to adapt to oil activity and about the availability of suitable alternative habitats. Further potential problems exist with drawing direct conclusions from the Prudhoe Bay developments, at least in the case of the Porcupine caribou herd (PCH). Nonetheless, the developments at Prudhoe Bay over a sustained period of time have not been adverse for most species. The FWS has taken special care to identify in the report areas of biological uncertainty. Biological conclusions that cannot be drawn with certainty have been noted as speculative. This is generally achieved by use of the word "could" or similar qualifiers.

A high degree of interest and concern for effects on caribou, specifically, the PCH, exists. Given the strong public interest and extensive interactions likely from oil development on the 1002 area for this species, the report includes a particularly detailed assessment of caribou. As described in a subsequent section, caribou is one of five evaluation species chosen for the resource assessment.

Because information directly relevant to probable reactions of the PCH to oil development is generally lacking, the FWS assessment team consulted with caribou biologists from the State of Alaska, the oil industry, universities, Canada, and within the FWS itself. In

Table VI-1.--Definitions of environmental effects.

Effect level	Definition
Physical environment	
Major.....	Widespread modification of considerable severity in landforms, surface appearance, or distribution of physical resources, or contamination of those resources, lasting several tens of years. Modification could occur during development/production phase.
Moderate	Local modification of considerable severity in landform, or surface appearance, or contamination of physical resources, lasting several tens of years; or widespread modification of lesser severity in surface appearance or other characteristics of physical resources, lasting from a few years to several tens of years. Modification could occur during the exploration phase.
Minor.....	Localized, relatively isolated change lasting from less than 1 year to no more than 10 years, with no observable residual modification in surface appearance, distribution, or other characteristics of physical resources.
Negligible	Little or no change in the surface appearance, distribution, or other characteristics of physical resources.
Biological environment	
Major.....	Widespread, long-term change in habitat availability or quality which would likely modify natural abundance or distribution of species. Modification will persist at least as long as modifying influences exist, that is, for the field life.
Moderate.....	Widespread, short-term (for less than the field life) change in habitat availability or quality which would likely modify natural abundance or distribution of species; or local modification in habitat availability or quality which would likely modify natural abundance or distribution at least as long as modifying influences exist.
Minor.....	Short-term (that is, for substantially less than the field life), local change of species abundance, distribution, habitat availability, or habitat quality.
Negligible.....	Little or no change in population, habitat availability, or habitat quality.
Human environment	
Major.....	Requires substantial changes in governmental policies, planning, or budgeting, or is likely to affect the economic or social well-being of residents.
Moderate.....	Requires some modification of governmental policies, planning, or budgeting, or may affect the economic or social well-being of residents.
Minor.....	Requires marginal change in governmental policies, planning, or budgeting, or may marginally affect the economic or social well-being of residents.
Negligible.....	Not sufficient to have any measurable effect on governmental policies, planning or budgeting, or any measurable effect on the economic or social well-being of residents.

November 1985, the team met with 14 of those biologists to specifically address the potential effects of oil development within the 1002 area on the PCH and Central Arctic caribou herd (CAH), and to compare the experiences gained from oil development at Prudhoe Bay and its effect on the CAH. These experts evaluated a scenario approximating the magnitude of development likely to occur from developing prospective areas identified by the BLM and GS in their preliminary studies. The location of development in that scenario was modified to prevent disclosure of any proprietary data.

On the basis of their studies of PCH and CAH biology, and of caribou reactions to arctic oil development and other disturbances, these experts provided the assessment team with information and ideas on the types and magnitude of possible effects. Recommendations on appropriate mitigation were developed during the workshop, and a report of the proceedings was prepared (Elison and others, 1986).

Although much has been learned from extensive studies of impacts on fish and wildlife species by oil development in the Prudhoe Bay area, analogies have been drawn with caution. Movements, densities, and traditions of caribou on the 1002(h) area are different from those at Prudhoe Bay or NPRA. Because of their greater numbers and density on the calving grounds, the PCH can be expected to encounter oil development more extensively and intensively than has the CAH at Prudhoe Bay. Because of this, available information does not allow a conclusive determination of impacts. However, the CEQ regulations require that when no information is available as to reasonably foreseeable significant adverse impacts, an agency must evaluate those impacts which have a low probability of occurrence but which could be expected to result in "catastrophic" (40 CFR 1502.22(b)) consequences if they do occur. The regulation further specifies that the analysis must be supported by credible scientific evidence, not be based on conjecture, and be within the rule of reason. Throughout the evaluation of environmental consequences where information is insufficient for a definitive analysis, this guidance was followed. Where information is unavailable, a conservative approach to impact evaluation has been used.

~ Mitigation Measures ~

Many potential effects of development can be avoided or minimized. The CEQ regulations require that an environmental impact statement include discussions of means to mitigate adverse environmental impacts of a proposed action and its alternatives (40 CFR 1502.16(h)). The measures recommended to mitigate impacts of oil development in this assessment were developed in consideration of the CEQ regulations and the FWS mitigation policy (46 FR 7644-7663, January 23, 1981). They were based on past North Slope industry practices and experience, and stipulations in various agreements, such as the Chandler Lake Agreement between the Department of the Interior and the Arctic Slope Regional Corporation.

The CEQ regulations define mitigation (40 CFR 1508.20) as: (a) avoiding the impact by not taking the action or parts of the action; (b) minimizing the impact by limiting the degree or magnitude of an action; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected area; (d) reducing or eliminating the impact over time by preservation and maintenance during the life of the project; and (e) compensating by replacing or providing substitute resources or environments.

The FWS mitigation policy is based on the CEQ definition of mitigation, and suggests planning goals to protect fish and wildlife resource values in areas proposed for development. These goals are used to guide the FWS when it makes recommendations to mitigate development impacts nationwide for a variety of projects, including Alaska North Slope oil and gas development (for example, Milne Point and Kuparuk).

This would occur, for example, under the authorities of the Fish and Wildlife Coordination Act and the Clean Water Act, when the FWS makes recommendations for mitigation to the Corps of Engineers in evaluating applications for permits required under Section 404 of the Clean Water Act. Once those applications are received by the Corps, they are forwarded to the FWS, among other reviewers, for comments and recommendations. The FWS makes its recommendations pursuant to the National Environmental Policy Act, as well as the Fish and Wildlife Coordination Act, and uses its mitigation policy as a standardized approach to offering mitigation recommendations nationally. This same approach would be expected to apply to the 1002 area, as it has elsewhere on the North Slope. With this in mind, the following is a brief description of the factors the FWS considers in formulating mitigation recommendations.

The mitigation policy calls for selection of fish and wildlife species (evaluation species) to use as indicators of habitat quality. Evaluation species have an important role in determining the extent and type of mitigation to be recommended. Five evaluation species were selected for the 1002 area (table VI-2). These species are of high public interest and have habitat requirements that represent the broad ecology of the region. They were used as the primary species for the programmatic impact analysis in this

Table VI-2.--Evaluation species for the 1002 area resource assessment.

Common name	Scientific name
Caribou	<u>Rangifer tarandus granti</u>
Muskox	<u>Ovibos moschatus</u>
Polar bear	<u>Ursus maritimus</u>
Snow goose	<u>Chen caerulescens</u>
Arctic char	<u>Salvelinus alpinus</u>

chapter; however, the other species and resource concerns described in Chapter II have also been considered. If the Congress chooses to open all or a part of the 1002 area for oil and gas development, site-specific evaluation of leased tracts could result in selection of different evaluation species which reflect the habitat values of that specific area.

Designation of resource categories is based upon the value of the habitat to the evaluation species. Table VI-3 lists resource categories outlined in the mitigation policy. The policy recommends that legally designated areas such as National Wildlife Refuges be given consideration as either Resource Category 1 or 2, in recognition of the special values for which an area was set aside. As described in Chapter II, high-value habitat occurs on the 1002 area for each of the five evaluation species selected for this assessment. Therefore, for this broad, programmatic analysis, the 1002 area has been designated overall as Resource Category 2 habitat. It is probable, however, that as site-specific development proceeds and the 1.5-million-acre area is broken into leasable tracts, different category designations will result. For example, on a site-specific basis, it would be expected that specific areas of habitat used mainly by shorebirds could be designated as Category 3 habitat. Conversely, if the plant Thlaspi arcticum is eventually listed as either threatened or endangered, the specifically defined areas in which it occurs would probably be elevated to Resource Category 1.

It should be understood that if the Congress directs the Secretary of the Interior to lease all or a part of the coastal plain of the Arctic Refuge, the mitigation policy of the FWS will be used as only one of the mechanisms available to ensure that development of the area proceeds in the most environmentally sound manner practicable. The list of recommended mitigation at the end of this chapter provides suggested environmental measures that could be used as appropriate throughout all phases of development. They have been based on application of CEQ's five elements of mitigation--avoiding, minimizing, rectifying, reducing or eliminating, and/or compensating for impacts. These, or other site-specific measures developed through early consultation, can ensure that no unnecessary adverse effects occur and that results of oil development are held within acceptable limits of loss to habitat values on the area.

~ Assumptions ~

Assumptions used in the assessments include:

1. The Secretary of the Interior would undertake early and continuous consultation and coordination with leaseholders, permittees, and State and Federal agencies from the start of planning. Performance standards would be developed for safety and

Table VI-3.--Resource categories and mitigation goals.

[FWS Mitigation Policy: FR, v. 46, no. 15, January 23, 1981, Habitat value: a measure of the suitability of an area to support a given evaluation species]

Resource category	Designation criteria of habitat to be affected	Mitigation planning goal
1	Habitat of high value for evaluation species. Unique and irreplaceable on a national basis or in the ecoregion.	No loss of existing habitat value.
2	Habitat of high value for evaluation species. Relatively scarce or becoming scarce on a national basis or in the ecoregion.	No net loss of in-kind habitat value.
3	Habitat of high to medium value for evaluation species. Relatively abundant on a national basis.	Minimize loss of in-kind habitat value. No net loss of value.
4	Habitat of medium to low value for evaluation species.	Minimize loss of habitat value.

environmental requirements. Site-specific mitigation measures, including design and construction techniques, would be addressed early in planning. These measures would be instituted in contracts and stipulations required in permits and in other authorizations required from regulatory agencies.

2. The Secretary of the Interior would be authorized to develop guidelines through regulations that would ensure the environmental integrity of the area.
3. Planning, design, construction, operation, maintenance, and rehabilitation would be accomplished using the most current available technology and practices. It is assumed that, as appropriate, the mitigation measures at the end of this chapter, or measures at least as effective, would be included in plans for development, construction, and operation, and would be implemented.

4. Any authorized oil and gas operations and related activities would comply with all applicable Federal and State laws and regulations, as well as with any special laws the Congress passes or regulations promulgated by the Secretary of the Interior to govern activities on the 1002 area.
5. Special protections for terrestrial and aquatic environments and cultural resources, and designation of special areas such as Sadlerochit Spring, found in guidelines governing the seismic exploration program on the 1002 area and the land-use stipulations for exploration drilling on the KIC/ASRC lands (August 9, 1983, agreement between ASRC and the United States) would continue to be in effect for oil and gas activities in the 1002 area. These stipulations may duplicate some of the mitigation measures recommended in this analysis, but they also include specific references to the handling and disposal of garbage, combustible and noncombustible solid wastes, used equipment, sewage and gray water, fuel and hazardous or toxic materials, and provision for hazardous substance control and contingency plans.
6. The recent interim conveyance to KIC/ASRC has been included on all maps used in this report. This 20,000-acre area was assessed in the draft LEIS and has been assessed in the final impact analysis. Although its removal from the analysis may result in a lower degree of impact assessment in a few cases, development activities which might occur if the area is opened can indicate part of the cumulative effects likely for the entire area. Consequently, inclusion of these lands in the analysis is reasonable.

ALTERNATIVE A--FULL LEASING

Effects on Physical Geography and Processes

Potential impacts on the physical environment (air, water, gravel, permafrost, and so forth) from a leasing program on the entire 1002 area would be generated from geological and geophysical (principally seismic) exploration; exploratory drilling; construction of all-season roads, oil transmission pipelines, and marine and other facilities required to support production.

GEOLOGICAL AND GEOPHYSICAL EXPLORATION

Additional surface geological surveys during the snow-free months would not be expected to affect the physical environment on the 1002 area. These surveys are brief: the investigators arrive by helicopter, study and measure geologic sections, perhaps take a few hand-sized samples of rock, and, at most, remain on the ground for a few hours. The principal effect is noise generated by the helicopter during arrival and departure.

~ Although the total line miles of new surveys might not differ much from the 1,336 line miles run previously on the 1002 area, more crews may be on the area. Different companies have different ideas as to where to concentrate detailed surveys (closer grid spacing); different types of data are useful to companies in their interpretations of subsurface geological structures or style. Additional crews could increase the overall impact, mainly from increased travel to and from the 1002 area. ~

The physical effects of seismic exploration generally result from overland movement of seismic vehicles. The effect is on the tundra which, if broken or scarred, can cause thawing of the upper ice-rich permafrost during the succeeding summers. Such thawing in flat areas will cause ponding at the junction of ice-wedge polygons, altering the appearance of the tundra landscape. If the thawing occurs on sloping ground, erosion can occur. If that erosion and its products terminate at a stream, local silting may result.

Mitigation

Surface effects of seismic surveys can be minimized by confining operations to the winter after the active soil layer is frozen to a depth of at least 12 inches and the average snow depth is about 6 inches. Seismic trains are generally routed through terrain where it is easier to move equipment, so potential for surface damage is minimized even though the routing may not provide the shortest travel distance. Gently sloping banks would be selected for the entry to and exit from all stream crossings, to reduce equipment strain and avert bank damage which could cause erosion and stream siltation. This is important on the 1002 area where, even though the topographic relief is not great, streambanks are steep along many drainages.

No ice roads or airstrips would be constructed to support seismic operations. Light, fixed-wing aircraft would be used for resupply, landing on 2,000-foot-long ice airstrips scraped on the nearest lake or pond. Ski-equipped aircraft can be landed on the snow-covered tundra if there are no lakes nearby.

Conclusion

The effect of seismic operations on water resources would be negligible. Seismic trains use about 2,000 gallons of water per day for domestic purposes. Where available, water is obtained from lakes that do not freeze to bottom. Where such lakes are not available, a small snow or ice melter is used to obtain domestic water supplies. Local noise and minor air pollution result from equipment operation; these effects are brief and transitory. Minor fuel spills may also occur.

~ EXPLORATORY DRILLING ~

Exploratory drilling requires heavy construction equipment to prepare a stable drilling pad, reserve pit, road to the water source(s), and airstrip. When the wellsite is completed, the drilling rig and support equipment are transported by Hercules C-130 aircraft or low-ground-pressure vehicles, depending on distances between well locations. The area disturbed by activity at the wellsite is usually about 10 acres, including the area for the reserve (mud) pit.

On the 1002 area, obtaining water for drilling and ancillary needs such as ice roads and airstrip construction has the potential for major adverse effects. Water is confined to surface areas; there are few lakes of any appreciable size.

As much as 15 million gallons of water may be needed to drill one exploratory well. Potential sources and methods to develop required water supplies were discussed in Chapter IV. Many streams containing deep pools that do not freeze completely in winter support overwintering fish populations. However, some rivers in the 1002 area do not support significant fish populations and there should be no need to disturb critical fish habitat.

Off-stream reservoirs could be created in conjunction with gravel-removal operations. They would be filled primarily by high (excess) streamflow during snow-melt periods (from about late May to mid-June) or summer rainstorms. These reservoirs would ideally be constructed in the unvegetated flood plain bordering the active stream channel. Depending on their size, their presence could have a visual impact insofar as they would contrast with naturally occurring features.

Mitigation

The use of double liners in reserve pits for both exploration and development wells is advantageous in adequately containing pit materials. When drilling is completed, the reserve pit could contain formation cuttings; drilling muds composed of barium, bentonite, and heavy metals (particularly iron, manganese, zinc, chromium, lead); salts (principally sodium chloride and potassium chloride); alkali (mainly calcium and magnesium bicarbonates); and possibly some liquid hydrocarbons. Detergents, biocides, and defoaming agents may also be present in the reserve pits, together with fillers, such as ground walnut shells. The amount of water introduced from snow that has blown into the pit depends on snow and fluid management practices.

~ Alaska solid waste regulations require the closeout of reserve pits at abandoned exploratory and development sites. Effective closure of these pits requires stabilizing the waste material (by drying), freezeback, filling, and providing an impermeable gravel cap to prevent leaching, as well as monitoring.

The accepted method for abandoning an exploratory well reserve pit is to inject the unfrozen fluid down the annulus of the well at the time drilling is completed and then fill the reserve pit with enough material so that the drilling mud and frozen fluid become a part of the permafrost. On the North Slope about 5 feet of cover material is required. If revegetation can be accomplished over the reserve pit, less fill is required to insulate the pit contents, due to the insulating properties of vegetation. Construction equipment is usually required to blade or haul fill material into the pit. The most successful technique for revegetation involves saving the top organic layer of the tundra when the reserve pit is excavated. This layer is then replaced when the pit is filled and abandoned.

Conclusion

Temporary minor contamination of the tundra could occur in the depression(s) where the treated gray water and other effluent is discharged from the camp's waste treatment plant.

Minor oil leaks and spills from operating equipment could occur. Human error and mechanical breakdown in a rigorous arctic environment create the potential for accidental spills of oil and other hazardous materials.

Short-term (one or two winter seasons) minor noise disturbance would be associated with operations. The visual effect of the drilling rig, construction camp, and transportation activities would similarly be a short-term, minor effect in the 1002 area.

Because of the temporary, highly localized nature of exploratory drilling, air-quality impacts would be negligible.

~ DEVELOPMENT AND PRODUCTION ~

Usually several million cubic yards of gravel are required to develop an oil field. In a tundra environment, adverse effects can be minimized by obtaining gravel from exposed and unvegetated bars along streams that are not fish-bearing. As long as the removal is limited to gravel exposed above the river ice or above the streambed (in those cases where the stream runs dry in winter), the watercourse would remain unchanged and no silting would occur because the gravels tend to be clean. In addition, the rivers in the 1002 area completely flush during the spring runoff.

The next places from which to obtain gravel with the least disruption are terraces immediately adjacent to river beds, using careful mining practices. Gravel may also be removed from cutbanks of a river with minimal disruption. The State of Alaska has been approving upland sites in recent years to prevent erosion, alterations of river features, and other physical problems, although this tends to create long-lasting visual effects.

Gravel, and sand in the absence of gravel, were obtained from river bars, river terraces, and cutbanks, in that order, during the construction of permanent airstrips and access roads for the deep exploration wells on the NPRA. Placing geosynthetic material (for example, styrofoam) and insulation below the gravel provides part of the insulation necessary for pads, and reduces the depth and overall gravel requirements.

The FWS has investigated the effects of reserve-pit fluid discharges on water quality and the fresh-water macro-invertebrate community of tundra ponds. The aquatic macro-invertebrates studied were indicator organisms for a wide variety of environmental pollutants and are important food sources for birds using the North Slope.

Preliminary results of the investigations show significantly higher alkalinity, hardness, and turbidity in ponds adjacent to reserve pits than in control ponds (R. L. West and E. Snyder-Conn, unpublished data). Significantly higher levels of heavy metals such as nickel, barium, chromium, and arsenic were found in ponds receiving effluent than in control ponds. There were also decreases in total taxa, taxa diversity, and invertebrate abundance in tundra ponds associated with reserve pits. Introductions of barite may have physically smothered benthic organisms as well as benthic stages of other organisms. The quality and quantity of organisms used as food by North Slope bird species may be decreasing with deterioration in water quality.

Impacts from use of reserve pits can also stem from the practice of using reserve pit fluids for "watering" roads to keep down the dust. The barite and heavy metals in these fluids lead to dust which is high in barium, chromium, lead, and possibly other metals (E. Snyder-Conn, FWS, unpublished data). The barium is in the form of very fine particulate matter which can be detected at elevated levels more than half a mile from roads and during summer months is apt to be far more predominant than dust from beaches, sand bars, and the like. Other metals occur at high concentrations in sediments nearer roads. Dust from these fluids also contribute to gradients of increased alkalinity, pH, and salinity depending on distance from the roads.

Possible effects of watering roads with reserve pit fluids are adverse impacts on invertebrates and on acid-loving plants. This could eventually affect grazing mammals and/or waterfowl and other birds. Inasmuch as the 1002 area is considerably drier than the Prudhoe Bay area, it is more likely that reserve pit fluids could be used on roads, because other local water sources are limited.

Chapter IV describes many of the siting and construction aspects of a pipeline to transport oil from the 1002 area to the Trans-Alaska Pipeline System (TAPS) Pump Station 1. An above-ground oil pipeline would not be as topographically confined in its routing as would the main road, and would be expected to be as straight as possible

but still minimize the lengths of the spur lines to central production facilities (CPF's). Thus, the distance between the pipeline and the work road could vary and occasionally the two might even cross, as with TAPS and the haul road (J. W. Dalton Highway) where they pass through similar topography. It is further assumed that the pipeline might cross some streams on vertical support members; in other instances the pipeline might be attached to the road bridge over the stream.

A pump station and feeder pipelines would be required at each CPF, and one or two booster pump stations would be positioned somewhere within the 1002 area, all of which are described in Chapter IV. CPF's, marine facilities, pump stations, and power-generation facilities to heat water lines running treated sea water to the CPF's would all be constructed on 5-foot-thick gravel pads. Pad areas would vary considerably, depending on the planned use, but consequences to the physical environment would vary mainly in degree.

Construction requirements could include 5-foot-thick drilling pads and 200-300 linear miles of all-season gravel roads within several oil fields, assuming discovery of multiple commercial-grade oil fields. The total number of pads and miles of road would depend on fields developed. Approximately 100 miles of road would be necessary east from the Canning River to the Pokok marine facilities. Construction of four, year-round, 5-foot-thick gravel C-130 airstrips could also be necessary.

Solid wastes generated from oil development in the 1002 area will probably require an incineration unit, a landfill, and an oily waste pit such as those operated by the North Slope Borough at Prudhoe Bay. The North Slope Borough landfill covers approximately 22 acres; the oily waste pit covers less than 10 acres. It may be possible to minimize losses due to a landfill by using an upland gravel pit for that site. Operations of solid wastes treatment facilities are regulated by the Alaska Department of Environmental Conservation.

Limited data available for the Prudhoe Bay area do not allow prediction of air-quality consequences of oil development within the 1002 area. The degree and kinds of air pollution will primarily depend on the chemical composition of the crude oil obtained and on combustion equipment design.

~ Air emissions will be generated by exploration, drilling, construction, excavation, vehicular and air traffic, pipelines, electrical generation, and oil production and associated facilities. The maximum annual emissions from the 1002 area would probably be analogous with present North Slope operations. Measurements in the Prudhoe Bay area for the period April 1979-March 1980 showed that the 24-hour maximum for total suspended particulates is sometimes violated and the 6-9 a.m. maximum for non-methane hydrocarbons was above National Ambient Air Quality and Alaska Department of Environmental

Conservation standards. However, the data show no violations in nitrogen dioxide, ozone, carbon monoxide, or sulfur dioxide. ~

~ With the exception of one recent Lisburne development well, all Prudhoe Bay/Kuparuk wells contain "sweet" crude oil low in hydrogen sulfide and, consequently, low in sulfur dioxide. Thus, acidification in the Prudhoe area is unlikely. The FWS has monitored the pH at numerous ponds and lakes in the Prudhoe Bay vicinity since 1983. The pH of most ponds and lakes and of snow in the Prudhoe field has been shown to be near pH 7 or higher, often above pH 8. The data clearly show that acidification has not occurred in the Prudhoe area. ~

Mitigation

Gravel requirements would be reduced by use of gravel-foam-timber pads where feasible. Gravel removal should be prohibited from active fish-bearing watercourses and their tributaries. Proper insulation should reduce permafrost degradation.

To ensure maintenance of water quality in the vicinity of drilling and production pads, drilling muds, cuttings and other wastes should be reinjected where geologically feasible. Reserve pits should be double-lined or otherwise rendered impermeable. Construction of "reservoirs" as a byproduct of gravel extraction could augment fresh-water availability.

Because reserve pit fluids would be minimized through water conservation, reuse, and reinjection, large quantities of these fluids would not be available for road watering to control dust. This will minimize contamination of adjacent tundra vegetation by the chemicals found in such fluids.

To reduce stream pollution, transportation crossings should be limited and permanent facilities should not be placed within 3/4 mile of the high-water mark of specified watercourses, determined on a site-specific basis.

All sources of air pollution in the 1002 area, whether or not they are related to oil and gas activities, must comply with applicable Environmental Protection Agency (EPA) and State of Alaska air pollution control requirements. It is, therefore, expected that these requirements are sufficient to ensure that any emissions generated in the 1002 area (or from related activities elsewhere) will not cause a significant deterioration of air quality.

Prior to any development, air-quality background data, chemical composition data on the crude oil to be produced, and data on sensitive vegetation should be gathered. These data together with air-quality modeling data are presented by unit producers to obtain a PSD (prevention of significant deterioration of air quality) permit. Under a cooperative agreement with the FWS, the National Park Service evaluates technical data in relation to Clean Air Act

Section 165 standards for National Wildlife Refuge areas. If it is determined that deterioration will exceed these standards using proposed emission equipment, a permit is not issued. The PSD permit process thus guards against unacceptable levels of adverse air quality impacts.

ARCO's recently installed Central Gas Facility in Prudhoe Bay contains improved flare equipment and has resulted in greatly improved combustion at that facility. These recent improvements in flare design should reduce potential air-quality degradation during emergency gas-flaring activities.

Conclusion

Moderate effects would be expected from translocation of gravel from natural sites to construction areas. This would change topography at borrow areas and at placement areas. Impacts at borrow areas would last well beyond the life of the project.

Localized removal or destruction of tundra vegetation resulting from the construction of gravel pads, gravel roads, and gravel mines could occur. Some thermokarsting (caused by the melting of ground ice and settling or caving of the ground surface so that pits, hummocks, depressions, and small ponds result) of the tundra would be expected. Permafrost may melt under borrow sites and under vegetation disturbed by other development activities. This would result in sloughing, erosion, and stream pollution lasting beyond the life of the project. Minor erosion in connection with culverts for in-field roads crossing minor drainages, some ponding upslope of airstrips, roads, and pads, and drying downslope of such pads would also be expected.

The dedicated industrial use of the limited natural fresh-water sources of the 1002 area would be a major effect.

At work sites during both the productive life of the fields and at restoration, noise generated by aircraft operations, drilling operations (especially that arising from power generation), and traffic would be major and continue throughout the field life. Similarly, the visual effect of such activities would be a major, long-term consequence of full leasing.

Current EPA and Alaska procedures and regulations are adequate to ensure no significant deterioration of air quality.

Effects on Biological Environment

Although this analysis treats species individually, the dynamic interrelationships existing among species and between species and their environments are recognized. Vegetation is a key component of the environment; it provides food and cover essential to all wildlife. Therefore,

a thorough discussion is presented under "Vegetation, Wetlands, and Terrain Types" regarding the effects of full development on that foundation of wildlife habitat. This forms the basis for later discussions of effects on individual species.

VEGETATION, WETLANDS, AND TERRAIN TYPES

GEOLOGICAL AND GEOPHYSICAL EXPLORATION

More detailed seismic surveys would create a closely spaced (2x2-mile or closer) network of temporarily visible trails over parts of the 1002 area. The effects of winter seismic trails would be similar to those from the 1984 and 1985 seismic operations--decreases in plant cover, changes in plant species composition, patches of exposed peat and mineral soil, destruction of hummocky microrelief, compression of the vegetative mat, deepening of the active soil layer, and surface depression of trails (Felix and Jorgenson, 1985; Felix and others, 1986a, b).

Trails through wet graminoid tundra and moist prostrate shrub scrub appear greener due to compression of standing dead leaves. Green trails may persist as a result of increased plant productivity and nutrient levels or changes in species composition in future years (Challinor and Gersper, 1975; Chapin and Shaver, 1981; EnviroSphere Company, 1985; Felix and others, 1986a, b).

On heavily disturbed trails, surface depression could occur due to compression and possibly subsidence. Standing water may be present on these trails. In moist graminoid tussock tundra or other vegetation types with hummocky microrelief, moundtops could be scraped or crushed. Trails here appear brown because of the exposed peat or increased litter from dead plants. The thin vegetation mat on dry prostrate shrub river terraces is easily disturbed, and large decreases in plant cover would be expected. Traffic through riparian areas could break shrubs, at some sites nearly to ground level. Most effects occur on narrow trails with multiple vehicle passes, and occur more often on trails made by mobile camp units and fuel or supply sleighs.

~ Mitigation ~

It is assumed that summer seismic exploration would not be permitted, and ice-road placement would continue to be prohibited in the same location 2 years in a row. Multiple vehicle passes over the same route should be avoided in all cases. Stipulations governing surface activities for the seismic programs in 1983-84 and 1984-85 (50 CFR Part 37) would also result in avoidance or minimization of impacts to vegetation.

~ Conclusion ~

Overall effects from additional seismic exploration would be minor or negligible.

EXPLORATORY DRILLING, DEVELOPMENT, AND PRODUCTION

If the entire 1002 area were leased, subsequent oil development, production, and transportation activities, and associated infrastructure would eventually result in approximately 5,000 acres of vegetation being covered by gravel for roads, pipelines, airstrips, and other facilities (table V-1), assuming all exploration is successful. Physical disturbances such as erosion and sedimentation, thermokarst, impoundments, clearing, gravel spray, dust, snowdrifts, and pollution would alter the habitat values of many more acres.

Effects on vegetation from ice roads and airstrips are not well-documented. It is generally thought that properly built ice roads protect vegetation from adverse impacts. Ice roads delay plant growth in the first year after use, and may appear as green trails for several years. Higher sites, common in the 1002 area, may be scraped during road construction or during use if the ice is not sufficiently thick (Adam, 1981). On Alaska State lands, ice roads are not allowed in the same location 2 years in a row to avoid compounding impacts on vegetation.

~ Well pads may be built of ice, gravel-timber-insulation, or gravel. Ice well pads have the least impact on vegetation, similar to that for ice roads and airstrips. Gravel-timber-insulation pads use timber/insulation in place of some gravel and often use reserve pit materials for any remaining gravel needs. This minimizes the need for gravel borrow pits and, thus, loss of vegetation. One disadvantage of the gravel-timber-insulation pads is that foam insulation can break down or erode into smaller pieces that can be very difficult to effectively remove from the tundra. When the timber and insulation are removed, a much thinner layer of material remains, often containing soil as well as gravel. ~

Rehabilitation is more successful for gravel-timber-insulation pads. Pioneer species are slow to colonize all-gravel pads because of limited nutrients, limited water availability, and lack of fine-grained materials (Everett and others, 1985).

~ To reduce the possibility of negative effects on vegetation, and eliminate the need for large reserve pits, subsurface disposal of drilling muds by reinjection should be used. This method is currently being used in some Alaskan oil fields and provides permanent disposal of contaminants. Overflow from reserve pits, breaching, or leaching may kill surrounding vegetation (French and Smith, 1980). Drilling muds may contain diesel fuel, soluble salts, heavy metals, and ethylene glycol, all of which can be toxic to vegetation (D. W. Smith and James, 1980). Improper closure of reserve pits can result in leaks or erosion (French, 1980). ~

Spills of diesel fuel, gasoline, crankcase oil, antifreeze, and hydraulic fluid could affect many small areas

of vegetation. During the 1984 and 1985 seismic exploration programs, reported spills include two spills of 50-100 gallons, 23 spills of 1-20 gallons and 46 spills of less than 1 gallon or of undetermined quantity.

Inasmuch as exploratory drilling requires large amounts of fuel, spills of much greater magnitude than those that occur during seismic exploration could occur. The extent of vegetation damage would depend on the time of year, type of material, size of spill, and vegetation type. Diesel fuel is highly toxic and kills all plants on contact; it may penetrate deeply into soil, killing roots and rhizomes and remaining toxic for decades (D. A. Walker and others, 1978; Lawson and others, 1978; Mackay and others, 1980). Spills in the winter are less toxic than summer spills. Winter spills are easier to contain and clean up, do not penetrate the soil as deeply, and lose some of their toxicity by evaporation.

Crude oil can cause severe decreases in vegetative cover but may not kill all vegetation, even in heavily saturated areas (Johnson and others, 1981). Mackay and others (1980) noted that crude oil degraded much faster than diesel, especially if it had not penetrated deeply into the soil. Revegetation sometimes began in less than 3 years. Areas where oil had penetrated deepest (20-30 mm) remained toxic for more than 4 years. Large spills inhibited recovery by altering the physical properties of the soils, making them drier, thus reducing or preventing seed germination and vegetative growth. Deep spills may also resurface in later years with toxic effects on the vegetation.

Because oil penetration is related to soil moisture, wet vegetation types undergo less initial damage. Standing water or saturated soils prevent fuel from penetrating to the roots or rhizomes. Wet sites also usually recover faster. In addition, those species most resistant to oil spills (sedges and deciduous shrubs) are the best recolonizers following disturbance (Walker and others, 1978).

Direct contact with oil often results in immediate damage to above-ground vegetation. Injury to the root system may not be immediately obvious, but can cause a slow deterioration of plants and a high degree of winter kill in future years (Deneke and others, 1975; Mackay and others, 1980).

~ Accidental spills of crude oil and refined petroleum products are an inevitable consequence of oil-field development. Throughout the operation of Prudhoe Bay, the very large spills (on the order of at least 10,000 gallons) have been of crude oil, gasoline, and diesel. Larger spills not only cover a larger area, but they also penetrate deeper into the soil. An indication of the frequency and volume of potential spills is provided by recent records for Prudhoe Bay. According to 1985 records (the first full year of computerized oil-spill data) there were 521 reported spills totaling 82,216 gallons (Alaska Department of Environmental Conservation, Fairbanks, unpublished data). Diesel and crude oil were the most commonly spilled products,

constituting nearly half the reported spills, with other petroleum products accounting for fewer spills. Most spills were small; 51 percent of spills were no more than 10 gallons, yet those spills equaled only 1 percent of the volume spilled in 1985. The most common causes of spills were leaks, ruptured lines, and tank overtopping. Effects have generally been localized. To date, the cumulative effect of spills has not been significant. ~

~ Culverts would need to be designed to ensure that slumping from roadcuts and erosion did not occur. Altered drainage patterns caused by roads and pads would result in some ponding, a generally wetter environment on the nearby upslope side of a road or pad, and a drier environment on the nearby downslope side. Impoundments caused by blocking drainages could cause changes in plant species composition or eliminate some plants depending on the depth and duration of flooding. Thermokarst, which commonly occurs on the edges of roads and pads, extends the affected area off the facility site and causes long-term changes in moisture conditions and plant species composition (Walker and others, 1984). ~

~ Gravel, dust, and changes in snow accumulation patterns would affect areas surrounding petroleum development facilities. Changes noted in the Prudhoe Bay oil field include:

1. Deposition of gravel spray 100 feet on either side of the road (Klinger and others, 1983; EnviroSphere, 1984; Walker and others, 1984).
2. Dust deposition as far as 250 feet from the roadside with heavy dust out to 80 feet (Everett, 1980; Klinger, 1983; Walker and others, 1984).
3. Early snowmelt along heavily traveled roads (Benson and others, 1975).

On the basis of this information, secondary effects from gravel and dust spray were assumed to extend 100 feet on each side of all roads. Impoundments and altered snowmelt patterns were also assumed to occur within this same 100-foot area, as the terrain in the 1002 area has greater relief and impoundments are not expected to be as extensive as those measured in the Prudhoe Bay oil field (Walker and others, 1984). Similar modifications would be expected adjacent to drill pads and other facilities. Therefore, approximately 7,000 acres of existing vegetation could be modified by these secondary effects. ~

An additional 500 to 750 acres may be mined for gravel at as many as 15 different locations, or by creating 20 to 30 deep holes for use as water reservoirs. The effects of gravel mines on vegetation depend on the location of the borrow pits, amount of gravel removed, and the vegetation type. Vegetation would not be directly affected if gravel were mined from unvegetated river bars, unvegetated coastal beaches, coastal lagoons, or lake bottoms. Borrow pits on partially vegetated river bars or vegetated river terraces would cause losses of alluvial

deciduous shrub and dry prostrate shrub river terraces, which cover only a small part of the 1002 area. In upland areas, vegetation would be lost in the area of the borrow pit, the area covered by overburden, and any area affected by erosion. Gravel removal in upland areas would be the most visually disruptive and would be extremely difficult to rehabilitate to pre-project natural conditions.

Pipelines may transport sea water from coastal marine facilities inland for waterflood or other purposes. The effects of sea-water spills on tundra vegetation are poorly understood, but depend on the spill size, season of occurrence, moisture, pH level of the site, and vegetation type. Sea-water spills affect dry sites more severely than wet sites. Sea water rapidly penetrates dry soil, resulting in high salt concentrations near the rooting zone. Recovery can take many years (Simmons and others, 1983). Sea water would be diluted and more rapidly flushed away at wet sites. Many wetland sedge and grass species are salt tolerant, but large sea-water spills that inundate the tundra could severely disturb vegetation, even in wet tundra sites. Major storm surges have killed all vegetation on flooded sites (Reimnitz and Maurer, 1979).

~ Mitigation ~

Effects on vegetation could be reduced by appropriate facility design and operation. Facilities should be consolidated as much as possible to avoid unnecessary direct loss of acreage. Culverts should be carefully designed to preclude impoundment problems. Traffic speed controls will reduce dust deposition. Reinjection of drilling muds and other fluids, and careful construction will help reduce toxic spills. Appropriate containment procedures and absorbent pads must be used to minimize and clean up any fuel, sea-water, or other spills which did occur. Effective cleanup procedures for spills and subsequent revegetation efforts can reduce the amount of vegetation originally affected and the length of time needed for recovery (McKendrick and Mitchell, 1978; Johnson, 1981; Pope and others, 1982; Brendel, 1985).

Rehabilitation of disturbed sites may partially restore lost habitat. Complete restoration may not be possible, inasmuch as construction activities dramatically alter surface features which determine plant species composition in the natural habitat. Several literature reviews of revegetation in Alaska have concluded that areas north of the Brooks Range are the most difficult to revegetate, and successful rehabilitation techniques have not yet been developed for these areas (Johnson and VanCleve, 1976; Johnson, 1981; Kubanis, 1982; Oakley, 1984).

Careful siting of petroleum exploration and development facilities and activities would be required to prevent disturbance of Thlaspi arcticum plants and their habitat. Some indirect plant loss might result from dust deposition. This species is currently under review to determine if it qualifies as a threatened or endangered plant (category 2 candidate--45 FR 82480). The widest known

distribution of Thlaspi arcticum in the Arctic Refuge is along the Katakaturuk River (pl. 1A), adjacent to potential economic prospects in Block A. Further study to better define the locations and numbers of Thlaspi arcticum plants occurring on the 1002 area, in conjunction with careful siting of pads and routing of collecting lines and associated roads in Block A, would avoid most impacts to that species.

~ Conclusion ~

An overall loss of approximately 5,650 acres (0.4 percent of the 1002 area) of existing vegetation could result, based on the estimated facility needs for developing the entire 1002 area. Habitat values would be lost when these habitats are covered by pads, airstrips, roads, and other support facilities.

Additionally, at least 7,000 acres could be modified by the secondary effects of gravel spray and dust deposition, altered snowmelt and erosion patterns, thermokarst, impoundments, and pollution. Habitat values would decrease to varying degrees.

The modification of approximately 12,650 acres (0.8 percent of the 1002 area) would be a minor effect (table VI-1) on area vegetation and wetlands.

~ SPECIAL TERRESTRIAL AND AQUATIC ENVIRONMENTS ~

SADLEROCHIT SPRING SPECIAL AREA

Within the 1002 area, the Sadlerochit Spring Special Area (approximately 4,000 acres) was the only area which was closed year-round to exploration activities during the previous exploration program. This was due to the spring's unique continuous flow of warm water, the only major flow of warm water in the 1002 area during the winter. Prohibiting surface occupancy and certain other activities in the Sadlerochit Spring Special Area would prevent most negative effects from oil development.

The increased human population expected under full leasing could increase use of the Sadlerochit Spring area, particularly by workers from adjacent Block D. The resulting increase in disturbance could cause muskoxen to avoid the area (pl. 2C) or could affect birds. In winter, the open water in the Sadlerochit Spring area provides habitat for the American dipper, one of only two passerine species resident year-round on the 1002 area (pl. 3C). Fishing pressure could also increase, competing with and disturbing Native subsistence users in the Sadlerochit Spring area (pl. 1B).

Mitigation

The existing "no surface occupancy" restriction for oil exploration and development should remain in effect. This precludes surface development and disturbance, thereby maintaining the area's physical features and important fish, wildlife, and subsistence resource values.

Conclusion

Under current protective management regulations, development as a result of leasing the entire 1002 area would have negligible effects on the Sadlerochit Spring Special Area.

KONGAKUT RIVER-BEAUFORT LAGOON

Based on the hypothetical development scenario, exploratory drilling and development activities are not expected, so there would be no impacts in this area. Further seismic exploration in this area could result in minor adverse impacts on vegetation and esthetic values. Minor amounts of local noise and air pollution would result from equipment operation. Temporary disturbance and/or displacement of wildlife could occur; these effects would be short-term. Minor fuel spills could also be expected.

Mitigation

Limiting surface occupancy in the zone from the coastline inland 3 miles would effectively mitigate impacts within this area.

Conclusion

Alternative A is expected to have negligible effects on the proposed Kongakut River-Beaufort Lagoon National Natural Landmark.

ANGUN PLAINS

Further seismic exploration could be expected in this area, resulting in minor adverse impacts on vegetation and esthetic values, temporary disturbance and/or displacement of wildlife, and minor fuel spills. Impacts on this area by exploratory drilling and development are expected to be negligible. If development activities do occur, the geologic features for which this area was identified as a potential National Natural Landmark would probably only be affected by gravel extraction.

Mitigation

Gravel extraction should be limited. Any proposal for gravel extraction within this area would be evaluated for possible adverse impacts on the geologic features which make this area unique.

Conclusion

Given the recommended mitigation, development as a result of fully leasing the 1002 area would have negligible effects on the proposed Angun Plains National Natural Landmark because it would not alter or disturb the area's natural characteristics.

JAGO RIVER

Under Alternative A the full range of development activities could be expected to occur within this general area (such as geological and geophysical exploration, exploratory drilling, developmental drilling, construction of roads, and pipelines). The environmental consequences of these activities have been described elsewhere.

Mitigation

It is recommended that the need for establishing "Research Natural Areas" on the North Slope be reviewed and specific locations (if any) within the Jago River drainage that meet these needs be identified.

Conclusion

Specific areas within the Jago River drainage have not yet been identified for inclusion in an "Ecological Reserve System," and so it is not possible to assess the projected development's effects on the proposed Jago River ecological reserve.

COASTAL AND MARINE ENVIRONMENT

Petroleum development and production in the 1002 area and associated transportation at both onshore and offshore sites would have a variety of effects. Docks and causeways can affect dispersion, nutrient transfer, temperatures, salinities, invertebrate abundance and diversity, fish passage, and other uses of those areas by fish and wildlife. Disruption of natural nearshore currents can result in sea-water intrusions into lagoons, causing lower water temperatures and higher salinities. Salinity and temperature changes could alter invertebrate abundance; decreases in invertebrates would mean lower coastal area values for fish and wildlife. Such intrusions may also alter fish movements by reducing existing favorable habitat conditions in nearshore zones.

Noise created by construction and other operations in coastal areas could be a disturbance, sufficiently reducing the quality of the coastal and marine habitats to cause avoidance by some marine birds and mammals.

Debris washing ashore from transport and offshore activities could increase with increased human activities in the area. The driftline is used for nesting habitat by several species of waterfowl and seabirds (pl. 3A, B, C). Disruption and physical alteration of the driftline by activities associated with oil development could affect bird nesting success by disturbing nesting birds or altering their nests. Debris and disruption of driftlines would also affect esthetics. Occasional fish and wildlife mortalities could occur where animals become entangled in or ingest debris.

~ Future developments on the North Slope of Alaska and in Canada, particularly those which are offshore of the 1002 area, could increase the level of effects in the coastal and marine environment. The cumulative effects of such developments would result in more intense activities at the port sites, possibly in longer causeways producing greater changes in the area's habitat characteristics as described above, in additional sources of noise and debris, and increased opportunities for oil spills. ~

~ Any spill of oil or other hazardous material along the coast could negatively affect coastal and marine habitats and fish and wildlife. For example, decreased invertebrates result in decreased food for fish and wildlife. Sea ducks, such as oldsquaw which heavily use this coastal area, could be displaced, and direct mortality could occur. Level of impact could range from major to negligible, depending on the volume of oil spilled, location, effectiveness of cleanup, time of year, and fish and wildlife species present. ~

Mitigation

Experience gained from construction and operation of docks and causeways for Prudhoe Bay should be used to plan and construct similar facilities for the 1002 area so that longshore water transport and lagoon water chemistry are not affected or fish movements impeded. Release of fuels and other hazardous substances should be minimized by developing and implementing control, use, and disposal plans for such substances.

Conclusion

Overall, the effect of full leasing is anticipated to be minor on coastal and marine habitats. A small probability of major adverse effects exists, depending on the extent and duration of future cumulative development or a catastrophic offshore or coastal oil spill.

TERRESTRIAL MAMMALS

~ CARIBOU ~

During the summer as many as 8,000 caribou of the 15,000-member Central Arctic herd (CAH) use the 1002 area to calve, forage, or seek relief from insect harassment. Individuals of the 180,000-member Porcupine caribou herd (PCH) have calved on the 1002 area in all years for which observations have been made (1972-86). In some years the entire PCH may use the area during the brief, late June-early July insect-relief period. Caribou of both herds are generally absent from the 1002 area in winter, although as many as 1,000 animals of the CAH have been observed scattered from the Sadlerochit Mountains to Camden Bay.

Analogies comparing effects of North Slope oil exploration and development on the CAH and possible effects of potential 1002 area development on the PCH are

drawn with caution. Movements, density, herd size, and traditions of the PCH differ from those of the CAH (Chapter II and Garner and Reynolds, 1986). As described by Whitten and Cameron (1985), the number of PCH caribou (including calves) per unit area of the calving grounds is nearly 14 times that of the CAH. The approximate densities are 24 caribou per square kilometer for the PCH and 5 caribou per square kilometer for the CAH. Because of this greater density the PCH would encounter oil development much more extensively throughout its summer range than the CAH does in the Prudhoe Bay area. Furthermore, wolves, brown bears, and other predators are more abundant adjacent to PCH concentrated calving areas; predator densities are relatively low near the CAH.

Exploration Impacts

Winter seismic programs on the 1002 area in 1984 and 1985, and exploratory well drilling on adjacent KIC/ASRC lands in the winters of 1985 and 1986 resulted in no apparent adverse effects on either herd. Similar results were found during seismic work in the NPRA within the range of the CAH (U.S. Bureau of Land Management, 1983). Winter oil exploration, including drilling, would not affect the PCH because they are not present then. Disturbance from well drilling in Block A could affect the CAH, resulting in some displacement; those caribou are sparsely distributed in Block A during the winter, so effects would be minor. Disturbance and displacement of the CAH and PCH from the short-term, scattered activities of summer surface geology exploration would be negligible.

Exploration Mitigation

Disturbance from exploration activities could be minimized and habitat values maintained by implementing environmental protection measures used during the previous seismic exploration program on the 1002 area (50 CFR 37.31) and the stipulations for exploration drilling on KIC/ASRC lands (agreement between ASRC and the United States, Appendix 2, Land Use Stipulations, Aug. 9, 1983). Oil exploration, except surface geology, should be limited to winter, generally November 1 to May 1, when most of the CAH and usually all the PCH are off the 1002 area.

Development Impacts

Effects on caribou from oil-field development, production, transportation, and rehabilitation would result from direct habitat modification, displacement, obstructions to movements which could reduce access to important habitats, and disturbance or harassment. The effects described herein assume successful oil exploration in all prospective areas. The greatest amount of development reasonably foreseeable to exist at some point in time was assessed.

The key determinant of impacts on caribou will be where development occurs, not necessarily how much. If adverse effects result, development in the southeast part of the 1002 area will have substantially greater effects on caribou than development elsewhere. Calving and insect relief were considered important functions which could be disrupted by activity in the 1002 area. Forage availability, predator avoidance, and free access to these habitats are other key factors considered in this assessment.

Effects of Habitat Modification.--If all prospective regions of the 1002 area were leased, successfully explored, and subsequently developed, directly modified caribou habitat--that is, the actual area covered by roads, airstrips, well pads, and other structures--could total approximately 5,650 acres. About 3,650 acres of this, east of the Sadlerochit River, would be used by the PCH; the remaining 2,000 acres west of the Sadlerochit River are used by the CAH. Direct and secondary habitat modifications due to changes in surface water flow, snow accumulation, roadside dust deposition, and so forth, as described in the previous section on impacts on vegetation, would reduce the habitat value of approximately 7,000 additional acres. Therefore, total modification of caribou habitat would occur on about 12,650 acres, or 0.8 percent of the 1002 area. This would represent losses in calving, insect-relief, foraging, and predator-avoidance habitats.

Mitigation of Effects of Habitat Modification.--These acreage figures were developed in consideration of mitigation measures that would require consolidated facilities siting and other measures to reduce the amount of actual acreage required. Careful road design and adequate culvert placement should ameliorate changes in surface water flow. Enforcement of speed limits and other traffic controls should reduce gravel spray and roadside dust deposition. Proper road maintenance should further minimize gravel spray and effects of altered snowmelt on adjacent vegetation.

Effects of Displacement and Disturbance.--Biologists participating in the FWS caribou assessment workshop agreed that displacement of PCH and CAH from areas of oil-related activities would occur (Elison and others, 1986). Historically the entire 1002 area has been used by caribou with minimal disturbance. Disturbance is unavoidable if oil development occurs on the 1002 area. It can result from a variety of causes--presence of pipelines and roads, aircraft operations, general construction, routine field operations, and the presence of humans. Reactions to disturbance depend on several factors including caribou age and sex, aggregation size, presence of calves, and the nature of disturbance. Cows with newborn calves are most sensitive to disturbance; bulls, barren cows, and yearlings are the least sensitive. In Prudhoe Bay, as many as 4,000 bulls, barren cows, and yearlings of the CAH remain near the development area.

Results of disturbance include avoiding development areas which can displace caribou from historically used habitats. Disturbance is generally believed to result more from human activity (noise, traffic, presence of people), than from the mere physical presence of the roads, pipelines, and buildings.

Caribou avoidance of development and human activity has been reported by numerous investigators (Dau and Cameron, 1985; Fancy, 1983; Urquhart, 1973; Wright and Fancy, 1980). The extent of displacement or decreased habitat use varies. Displacement of the CAH from historic calving grounds in response to oil development at Prudhoe Bay has been documented (Dau and Cameron, 1985; Cameron and Whitten, 1979).

Aircraft disturbance of caribou has also been documented. For example, Calef and others (1976) reported that helicopters which hazed caribou from the rear caused a severe panic reaction. Large numbers (up to 60,000 animals) could be herded by flying at altitudes of up to 2,000 feet above ground level (AGL). Calves were more sensitive than other age classes and caribou on calving grounds reacted the most.

Effects of disturbance and displacement on caribou calving, insect-relief, and other activities are detailed below.

Effects on Calving from Displacement/Disturbance.--Plates 2A and 2B show substantial overlap of potential oil development facilities on the 1002 area with PCH calving areas, and a smaller overlap with CAH calving areas. It has been hypothesized that caribou select calving areas because of early snowmelt, advanced emergence of new vegetation, relative absence of predators, proximity to insect-relief habitat, lack of disturbance, or some combination of these and other factors (Cameron, 1983). Maternal cows and their calves are most sensitive during calving and immediately thereafter (Calef and others, 1976; Miller and Gunn, 1979; Elison and others, 1986). Disturbance to cow-calf groups on the calving grounds could interfere with bond formation and increase calf mortality.

Concentrated calving areas depicted on figure II-5 and plate 2A have been used by caribou in densities ranging from 46 to 128 caribou per square mile (1983-86). As described in Chapter II, densities of similar magnitude are assumed for earlier years. Oil development in these areas is of particular concern. Twenty-seven percent of the concentrated calving areas used by the PCH (1972-86) are within the 1002 area. When compared with the CAH, the PCH is much more crowded on its calving grounds, but of greater importance is that substantially more of its concentrated calving area may be developed.

Dau and Cameron (1986) reported that maternal groups of CAH caribou showed declines in habitat use within 3 kilometers (km) of either side of the road in the North Slope's Milne Point oil field. Further review of the Dau and Cameron data shows that statistically significant declines in use occurred out to 1 km (P=0.05) and 2 km (P=0.1). Dau and Cameron compared the distribution of caribou during the 4 years (1978-81) before construction of the 29-km-long road and the 4 years (1982-85) after construction, which occurred during the winter of 1981-82. The road was constructed through one of the two reported CAH concentrated calving areas (Shideler, 1986).

For all caribou and for calves, linear relationships between caribou density and distance from the Milne Point road differed significantly for the two periods. After road construction, fewer adult caribou and calves were in the 3 km closest to the road. Greater numbers of adults and calves than normally expected were in the area 3-6 km away from the road. The data show that the area within 3 km of the road had about 50 percent of the number of caribou that used the area prior to construction. Most adult caribou in the study area were maternal cows; their displacement and that of calves were most noticeable. Effects decreased as the distance from the road increased.

It is important to note that the Milne Point field is the smallest development area on the North Slope. Activity levels were low (fewer than 10 vehicle trips per day) and there was one active drill rig during 2 of the 4 years of

post-construction study. Under full leasing, most roads in the 1002 area would be expected to have much greater traffic. There would be more drill rigs and other facilities in many areas. Thus, predicted results in the 1002 area, using the Milne Point study as a basis, are likely to be conservative.

For this assessment, a 3-km sphere of influence was assumed, on the basis of the Milne Point study. If this is applied to the development scenario for Alternative A, about 303,000 acres of PCH concentrated calving habitat (table VI-4) could be affected. This represents about 37 percent of total concentrated calving habitat within the 1002 area, of which approximately 130,000 acres are within the statistically significant (P=0.05) 1-km area and an additional 104,000 acres are within the statistically significant (P=0.1) 1- to 2-km area. These areas would mainly be avoided by pregnant or parturient cows and calves. Total avoidance up to 3 km from the Milne Point road did not occur, and total avoidance of the 303,000 acres within 3 km of the Alternative A development scenario would not be expected. Calving would occur throughout the area at reduced levels with the decline in habitat use varying inversely with distance from the road or other development.

Pank and others (1987) estimated the extent to which individual caribou could come in contact with development activities. They analyzed daily movements of 10 adult caribou cows relative to the Alternative A scenario (fig. V-1

~ **Table VI-4.**-- Porcupine caribou herd concentrated calving area potentially affected by development under full leasing or limited leasing, assuming a 3-kilometer sphere of influence. ~

	Acres		
	0-1 km	1-2 km	0-3 km
Total concentrated calving area in the United States and Canada	3,046,000		
Total concentrated calving area within the 1002 area	828,000		
	Sphere of influence		
	0-1 km	1-2 km	0-3 km
Area (acres) potentially influenced by development:			
Full leasing	130,000	104,000	303,000
Limited leasing	96,000	72,000	214,000
Percent of 1002 calving area potentially influenced by development:			
Full leasing	16	13	37
Limited leasing	12	9	26
Percent of total U.S. and Canada area potentially influenced by development:			
Full leasing	4	3	10
Limited leasing	3	2	7

and table V-1). The caribou--two from the CAH and eight from the PCH--had been radio-collared on winter range in the Arctic Refuge. Assuming no facilities completely obstruct caribou movements, the satellite-telemetry data showed that 34 percent of routes taken by collared PCH caribou were within 3 km of possible development infrastructure. The two CAH caribou would have encountered development on 83 percent of their routes. Annual variations in movement patterns and the limited sample size and timeframe of the analysis must be recognized in reviewing these findings. Still, they provide a preliminary indication of the extent to which activity patterns of some caribou could interact with development.

Although there is no evidence that the initial Prudhoe Bay development area was ever a concentrated or highly preferred CAH calving area (Shideler, 1986), some calving occurred there when development began (Child, 1973; White and others, 1975). Later studies indicate an absence of calving near the coast at Prudhoe Bay during 1976-85, possibly due to avoidance of development activity (Cameron and Whitten, 1979, 1980; Whitten and Cameron, 1985). Table VI-5 compares calving in the Prudhoe Bay area and the population size of the CAH to development of the Prudhoe Bay oil field.

As evidenced by the dramatic increase in CAH numbers, displacement appears to have had no significant adverse effect. In considering effects of displacement of the CAH from calving grounds, Whitten and Cameron (1985) contend that the CAH has not experienced a reduction in productivity or a consequent population decline, because: (1) suitable alternative high-quality habitat appears available; (2) the CAH has been displaced from only a part of its calving grounds to areas already used for calving; and (3) overall density of CAH caribou on their calving grounds (even after displacement) is much lower than the density of other Alaskan Arctic caribou herds.

Because CAH calving density is low, overcrowding and consequent habitat stress that might result in reduced productivity and survival have not yet occurred, despite the herd's population increase. Nor have CAH caribou been displaced to areas of apparently reduced habitat value or increased predation. The CAH has been exposed to minimal predation in recent years. With the influx of workers and use of the Dalton Highway for Prudhoe Bay development, the wolf population in the central Arctic decreased in the mid-1970's as a result of illegal hunting. At that time CAH numbers began increasing. The wolf population has remained low and brown bears, which also prey on caribou, are only moderately abundant in the area.

Mitigation for Effects on Caribou Calving.--Nonessential development facilities should be located outside concentrated calving areas and riparian habitats (pl. 2A). Essential facilities (drill pads and associated pipelines/roads) should be consolidated so as to minimize acreage requirements, and should be constructed and maintained to minimize disturbance. Time and area closures should be

established, or restrictions on activities and access imposed, during critical periods in areas of caribou concentration--for calving, approximately May 15-June 20. Off-road vehicle use should be prohibited within 5 miles of all pipelines, pads, roads, and other facilities, except for traditional use by local subsistence users. Methods to facilitate caribou passage at pipelines (as discussed in the insect-relief section below) would also facilitate access to calving habitats.

~ **Table VI-5.**--Central Arctic caribou herd population, calving in Prudhoe Bay area, and Prudhoe Bay development activities, 1969-85. ~

[Information from Shideler (1986); some variation exists in calving areas surveyed. Long-term investigations of the CAH begun in 1974 by the Alaska Department of Fish and Game. N.A., not available]

Year	Total CAH population	Number cows and calves	Development activities
1969-70	(1)	(1)	Oil discovered.
1972	N.A.	13	Deadhorse airport, road system, several drill pads developed.
1973	N.A.	42	
1974	N.A.	51	Construction of TAPS; rapid area growth in roads, facilities, and drill pads.
1976	N.A.	(2)	Oil production begins.
1978	6,000	(3)	Drill sites and road connecting Kuparuk with Prudhoe Bay developed.
1981	9,000	N.A.	Kuparuk pipeline connecting to TAPS completed.
1983	13,000 (4)	0	Expansion of Kuparuk oil field.
1985	15,000 (5)	N.A.	Pipeline to Milne Point constructed.

¹Reports of area used for calving by the 3,000 or so caribou residing in Prudhoe Bay area, early 1970's.

²A handful.

³About 10.

⁴From photocensus (Smith, 1985).

⁵Extrapolated from photocensus based on mortality and productivity estimate.

Recommendations for aircraft restrictions differ. According to Calef and others (1976), flight elevations of 500 feet AGL would prevent most injury-causing caribou reactions (for example, stampedes). Altitudes of 1,000 feet AGL would avoid mild escape responses. These investigators recommended aircraft altitudes of 1,000 feet AGL during calving, rut, and early winter. Davis and Valkenburg (1979), who also noted an inverse relationship between the altitude of aircraft and severity of caribou reactions, recommended altitudes of 2,000 feet AGL from May to August. Caribou of the Peary herd in Canada reacted similarly to helicopters (Miller and Gunn, 1979); altitudes of 2,000 feet AGL were recommended for May to November and 1,000 feet AGL at other times. The FWS does not have authority to regulate minimum flight altitudes, but can enforce aircraft harassment prohibitions.

Effects on Other Activities from Displacement/Disturbance.--
Dau (1986) recently investigated the distribution and behavior of caribou on Alaska's North Slope in relation to weather and parasitic insects. During the brief summer season caribou attempt to optimize foraging to meet the needs of lactation and growth, and to build body reserves for the coming winter. Abundant high-quality forage occurs inland from the coast. Nonetheless, during warm, calm days which favor insect activity, large numbers of caribou seek insect relief by moving to the cooler, breezier coast. Summer activity patterns are characterized by pulsating movements between coastal insect-relief areas and optimal inland foraging areas, in response to the frequent weather changes.

In the absence of available insect-relief habitat, caribou aggregate into large groups or continue to move into the wind without feeding. If the period of insect harassment is extensive, weight loss ensues. This detrimental effect is in addition to the loss of blood (up to 125 grams/day) to mosquitoes and the increased parasitism from skin warbles and nasal bot flies. Investigations of caribou-insect relationships indicate that in a typical July in the Kuparuk oil field, conditions for severe insect harassment occur on 10 days and mild harassment occurs an additional 12 days.

If caribou are delayed or prevented from free access to insect-relief habitat, the result may be deterioration in body condition with consequences of decreased growth, increased winter mortality, and lowered herd productivity (Dau, 1986).

Reduced access to important insect-relief, forage, and predator-avoidance habitats could result from development on the 1002 area. Postcalving aggregations could be inhibited from moving between inland feeding areas and coastal or mountainous insect-relief habitats within and to the south of the 1002 area as a result of development.

Several investigators have described inhibited passage of caribou through developed areas due to linear oil-development facilities and associated activities (Curatolo

and others, 1982; Smith and Cameron, 1985a, b; Klein, 1980). This is of concern in the 1002 area because the probable main pipeline/haul road route would bisect the area, rather than run parallel to caribou movements as it does in the Prudhoe Bay development. The probability of avoidance, though unknown, is anticipated to be low for bachelor bulls and high for maternal cows and calves (Elison and others, 1986).

Studies at Prudhoe Bay show varying successes of caribou in crossing roads and pipelines (Fancy, 1983; Curatolo, 1984; Curatolo and Murphy, 1983; Smith and Cameron, 1985a, b). Crossing success appears to depend on factors such as traffic and other activity, pipeline design, season, and insect harassment. Caribou usually cross roads freely if traffic levels are low and avoid heavy traffic (Curatolo and others, 1982). In summarizing the 1981-83 studies of caribou crossing in the Prudhoe Bay and Kuparuk oil fields, Curatolo and Murphy (1986) attributed lower crossing frequencies at pipeline/road sites to the combined stimulus of vehicle traffic and a pipeline. In studies involving effects of the Kuparuk pipelines and roads, Curatolo and others (1982) found that for roads with no traffic, caribou reactions ranged from no observable reaction to actually selecting the road for oestrid fly relief.

During the oestrid (nose bot and warble) fly harassment period from late July to early August caribou seek relief on gravel roads and well pads or in the shade of pipelines and buildings (Curatolo, 1983; Fancy, 1983). The insect harassment period for the PCH while on the 1002 area is brief, and the majority of the PCH is usually gone from the 1002 area before oestrid fly season peaks. The primary source of insect harassment for the PCH while on the 1002 area is generally the swarms of mosquitoes early in the summer season. Large groups of mosquito-harassed caribou do not readily pass beneath elevated pipelines (Curatolo and Murphy, 1983; Smith and Cameron, 1985b). Deflections of up to 20 miles, during which caribou ran or trotted, have been observed in the central Arctic.

Smith and Cameron (1985a, b) and Curatolo and Murphy (1983) documented reduced crossing success where caribou have been exposed annually to major oil and gas development for extended periods since the early 1970's. Because some habituation would presumably have occurred, the CAH may be more likely to cross an oil-field development in the 1002 area than would the PCH. Elison and others (1986) agreed they did not know how much habituation would occur over time. Even large groups (1,000 animals) in the CAH that successfully negotiate structures like pipelines are much smaller than the PCH postcalving aggregations (up to 80,000). If the larger PCH groups react negatively, as Smith and Cameron suggest, there could be significant exclusion of PCH caribou from coastal areas.

The amount of PCH insect-relief habitat which could be avoided may be quantified in two ways. Eighteen percent (294,000 acres) of the 1002 area and adjacent

KIC/ASRC lands lies north of the proposed pipeline/road corridor analyzed for Alternative A. If caribou are inhibited by road/pipeline development, then use of 52 percent of estimated insect-relief habitats (including as much as 80 percent of the coastal habitat) could be reduced. Alternatively, by using the 3-km zone of influence described for calving, habitat use on as many as 72,000 acres (29 percent) of insect-relief habitat within the 1002 area and KIC/ASRC lands could be reduced (Pank and others, 1987). Decreased use of the insect-relief areas would be greatest for cows with calves. If caribou avoid coastal insect-relief habitat, they may compensate by using the foothills south of the 1002 area, although this area may be less favorable due to higher predator densities.

Mitigation for Effects on Other Activities.--Time and area closures should be established, restrictions on activities and access imposed, or traffic controlled during periods when caribou actively seek out insect-relief, forage, and predator-avoidance habitats--approximately June 20-August 15. Curatolo and Murphy (1983) suggested that caribou passage could be facilitated by separating pipelines from heavily traveled roads and constructing ramps at strategic locations over elevated pipelines. Other researchers have concurred (Curatolo and others, 1982; Robus and Curatolo, 1983; Elison and others, 1986). The optimum separation depends upon terrain. Preliminary information indicates that a separation of 400-800 feet improves crossing success (Curatolo and Reges, 1986). To permit use of coastal insect-relief habitats, all methods to facilitate caribou passage should be used, as appropriate and feasible (that is, elevating, ramping or burying pipelines; separating pipelines and roads; and implementing time and area closures, as well as access restrictions, for vehicles and activities).

From the coastline inland 3 miles, surface occupancy should be restricted to marine facilities and other infrastructure essential to support inland activities. Drill pads and production facilities could be allowed within the zone 1.5 to 3 miles from the coast, on a site-specific, case-by-case basis only.

Conclusion

Major effects on the PCH could result if the entire 1002 area were leased and all oil prospects contained economically recoverable oil. Leasing and developing the southeast quadrant of the 1002 area could result in the greatest degree of effect on the PCH. This conclusion assumes all recommended mitigation measures are in place and effective, and considers peak levels of activity. The effects of oil development on caribou would need to be monitored and studies of caribou populations, productivity, movements, distributions, and general health would need to continue, to ensure that mitigation measures were effectively applied and to ascertain actual effects of development.

If this major effect occurred, it would manifest itself as a widespread, long-term change in habitat availability or quality which would likely modify natural abundance or distribution of the PCH in the 1002 area. This modification could persist at least as long as modifying influences of oil production exist (table VI-1). "Catastrophic" consequences (40 CFR 1502.22(b)(4)) are not expected to occur; but if significant adverse effects coincided with a population low in the natural fluctuations, their effects would be greater than at a population high.

There is risk that displacing the PCH from historically used habitats could result in significant long-term changes in distribution, adversely affecting habitat use and behavior patterns. The main oil pipeline would bisect the 1002 area between the western and northeastern boundaries. Disturbance would occur from the presence and activities of up to 6,000 people, many vehicles, and major construction and production activities throughout the 1002 area, including sensitive, repeatedly used, concentrated calving areas.

Approximately 37 percent of PCH concentrated calving habitat could be affected. Sixteen percent of this area is within 1 km of the full development scenario, an additional 12 percent is within 1 to 2 km and another 9 percent is within 2 to 3 km (table VI-5). A decline in caribou use of the area within 3 km of full development is expected. Significant declines in use by maternal cows and calves could occur within at least the 2-km zone.

A significant portion of the most repeatedly used concentrated calving area in the upper Jago River drainage is within the 1-, 2-, and 3-km zones adjacent to development. If the area used for concentrated calving in approximately half the years for which detailed observations exist (7 of the 15 years, 1972-86) is considered (fig. II-5 and pl. 2A), then caribou avoidance could occur within 48 percent of the most repeatedly used PCH calving area (18 percent at 1 km, an additional 18 percent from 1 to 2 km, and another 12 percent from 2 to 3 km).

Use of 29-52 percent of estimated insect-relief habitats within the 1002 area and KIC/ASRC lands also could be substantially reduced. Failure to obtain insect-relief could lead to poor physical condition, increased susceptibility to predation if insect-relief areas south of the 1002 area are sought out as an alternative, and reduced over-winter survival. This could disproportionately affect cows with calves, which could be expected to reduce recruitment. Reduced habitat values on the 1002 area because of obstacles to free movements for foraging and predator avoidance could similarly affect caribou.

Although no recognizable long-term effect upon the CAH as a result of displacement by oil development in the central Arctic has been demonstrated to date, loss of important habitat has been shown to directly impact ungulate populations (Wolfe, 1978; Skovlin, 1982).

Reductions in calving habitat values, reduced access to insect-relief areas, obstacles to free movement required for foraging and predator avoidance, increased energy expenditure as a result of disturbance, higher levels of stress, and other factors could cumulatively affect caribou physiology.

A change in distribution of the PCH could reasonably be expected. The potential for occurrence of a population decline resulting from loss of habitat and reduction in habitat values cannot be predicted nor the size of a decline estimated. Nevertheless, there is a risk that a decline could occur. However, no appreciable population decline is expected as a result of oil development.

For the CAH, the change in their distribution on the 1002 area could be moderate. However, the effect on the entire CAH population throughout its range would be minor. The effects on the segment of the CAH within the 1002 area would be generated from disturbance, displacement and obstructions to free movement.

~ MUSKOXEN ~

Recently reintroduced to the Arctic Refuge, muskoxen are rapidly expanding their range and pioneering new areas. The population has grown from the 64 muskoxen introduced in 1969-70 to 476 in 1985. Carrying capacity has apparently not been reached.

Direct loss of muskoxen habitat from oil development could total approximately 2,700 acres (pl. 2C). Information is scanty regarding the reaction of muskoxen to oil-field development and operation. Disturbance caused by routine oil-field operation and associated infrastructure could be expected to exclude or reduce muskoxen from use of their preferred habitats. Muskoxen resident on the 1002 area would be exposed to year-round activity.

Muskoxen are present on the 1002 area throughout the winter when most exploration and construction activities would take place. Daily muskox activity decreases during winter (Reynolds, 1987) as part of their behavioral strategy for energy conservation. Repeated disturbance during the winter causing increased or prolonged muskox activity would result in energy drains which could adversely affect survival of individuals and productivity of pregnant females.

Effects of stress on muskoxen have been difficult to measure. Miller and Gunn (1979) concluded that lack of visible response does not necessarily mean the absence of physiological changes or energy drain which may have a major effect on the population over time. The amount of physiological stress required to increase mortality or decrease productivity is not known.

In their extensive study of muskoxen reaction to helicopter disturbance on Banks Island, Northwest Territories, Canada, Miller and Gunn (1979) reported that cows and calves and solitary bulls were the most responsive; the reaction was similar to response to a predator; and the degree of reaction was generally inversely related to the distance of the helicopter. The presence of people on the ground in association with helicopters that had landed increased the disturbance. Although muskoxen disturbed by helicopters usually moved less than 0.2 mile, Miller and Gunn (1979) recommended minimum altitudes of 2,000 feet AGL during May-November and 1,000 feet AGL during December-April. Muskox reaction to helicopters can depend on a wide number of variables--sex and age of animals, group size, number of calves in a group, the position of the sun and direction of the wind relative to the disturbance, what the animals are doing at the time of disturbance, and terrain (Miller and Gunn, 1979). Harassment may result in a net energy drain if it occurs during the critical winter period, and can thereby reduce survival.

Muskoxen also respond to seismic vehicles. Experience in the 1002 area from winter seismic exploration in 1984 and 1985 and summer surface exploration in 1983, 1984, and 1985 indicates that these activities had only minor disturbance effects. One herd was reported to have run about 0.6 mile after being disturbed by seismic vehicles 1.9 miles away (Reynolds and LaPlant, 1985). They reported no long-term or widespread changes in distribution or use of traditional areas in response to this disturbance. Jingfors and Lassen (1984) also found that muskoxen disturbed by seismic vehicles either ran or gradually moved away. Other investigators (Carruthers, 1976; Russell, 1977) reported similar responses in Canada. Temporary displacement of up to 2 miles has been observed on both sides of seismic lines (Russell, 1977). Although oil-field development and operation would be much more intrusive and sustained than seismic exploration, the increased disturbance may be partially offset by habituation which has been observed by Miller and Gunn (1979) during experimental helicopter harassment.

Muskoxen frequent riparian areas which could be major sources for gravel needed for construction. Important

forage areas may be lost due to displacement and habitat destruction.

As described in the previous section on caribou, loss of important habitat has been shown to have major negative effects on ungulates. Muskoxen have a high fidelity to relatively small areas and presumably select them because of factors favorable to herd productivity and survival: availability of preferred forage, better weather or snow conditions, relative absence of predators, lack of disturbance, or some combination of these and other factors. Displacement from high-use areas could have a negative effect on muskox production. The magnitude of that effect is difficult to accurately predict, particularly in view of the expanding nature of the population, but would likely be related to the magnitude and duration of displacement. No information is available on the reaction of muskoxen to sustained oil-development and production activities.

Based on the displacement observed by Russell (1977) and Reynolds and LaPlant (1985) resulting from seismic activities, a 2-mile sphere of influence was assumed in calculating the muskox range which could be affected by full leasing. Given the much lower level of activities and resultant disturbance from seismic exploration as compared to construction and production phases of oil development, this assumption may be conservative. Consequently, table VI-6 shows that habitat values could be lost or greatly reduced throughout about one-third (256,000 acres) of the muskox range within the 1002 area. Habitats used for high seasonal or year-round use, including calving, would be disproportionately affected; habitat values could be reduced in up to 53 percent of those habitats. Habitat values could be lost or reduced on nearly 75 percent of the high-use calving habitats. Such a large percentage of loss in

valuable calving habitat could have a negative influence on herd productivity.

Direct mortality could result from hunting, vehicle collisions, and other accidents associated with development. Muskoxen are highly vulnerable to hunting, and direct mortality would be expected to increase over time as access into previously undeveloped areas increased.

Mitigation

Negative effects on muskoxen could be mitigated by prohibiting disturbance and implementing necessary time and area closures similar to the measures described for caribou. Continued monitoring of the population's growth, distribution, movements, and behavioral responses would detect changes and determine what, if any, additional mitigation may be needed.

Because riparian areas are favored habitats, closure of important riparian areas to siting of permanent facilities and limiting crossings of those areas by transportation facilities would minimize potential interactions and disturbance, which would reduce effects on muskoxen (pl. 2C).

Increased hunting regulation and enforcement would be required to regulate harvest.

Conclusion

Major negative effects on the 1002 area muskox population could occur from oil development, based on the possible displacement from preferred habitats.

Table VI-6.--Observed muskox range potentially affected by development under full leasing or limited leasing, assuming a 2-mile sphere of influence.

	High-use range seasonally or year-round		Other range	Total range
	Without calving	With calving		
Total muskox range (acres) within Arctic Refuge.....	251,000	211,000	654,000	1,116,000
Area (acres) within development sphere of influence:				
Full leasing.....	46,000	112,000	98,000	256,000
Limited leasing.....	46,000	110,000	98,000	254,000
Percent of Arctic Refuge range influenced by development:				
Full leasing.....	18	53	15	23
Limited leasing.....	18	52	15	23
Total muskox range (acres) within 1002 area.....	207,000	158,000	395,000	760,000
Percent of 1002 area influenced by development:				
Full leasing.....	22	71	25	34
Limited leasing.....	22	70	25	33

Muskoxen could be displaced from a significant portion of high-use habitats used year-round and for calving, with a probable decline in productivity. This, coupled with any direct mortality and the unavoidable disturbances expected, could cause a decline in the population rate of growth and a change in distribution. Effects would be most pronounced on the small isolated subpopulation of approximately 80 animals using the Niguanak-Okerokovik-Angun River area, in the eastern part of the 1002 area.

Predicting changes in muskox numbers as a result of petroleum development would be highly speculative. There are no references in the literature to analogous activities in other muskox ranges.

As noted elsewhere in this report, muskoxen are being reestablished in Alaska. Oil development on the 1002 area is unlikely to affect this overall re-establishment effort.

MOOSE

The 1002 area is not high-quality moose habitat. Peak use is during the summer when the population probably is less than 25; during the winter, moose are rare on the area. The portion of the total refuge population represented by this figure is not known.

Direct loss of habitat is expected to be about 140 acres out of the 96,000 acres of the 1002 area identified as moose-use areas. Affected areas are low-density habitats (less than one moose per 26 square miles), mainly in Block D (pl. 1C).

Moose adapt readily and habituate to the presence of human activity; they are not easily disturbed (Denniston, 1956; Peterson, 1955). They have expanded their range in North America at the same time that human disturbance has spread (Davis and Franzmann, 1979). On the Kenai National Wildlife Refuge in Alaska, helicopter-supported winter seismic surveys using explosives did not modify moose distribution patterns, movements, or behavior (Bangs and Bailey, 1982). Most studies have dealt with moose in forested areas. The response of moose to disturbance in tundra areas has not been demonstrated.

Increased human development on the Kenai Peninsula, Alaska, has resulted in increased moose mortality from hunting, collisions with vehicles, poaching, and other causes (Bangs and others, 1982). Moose mortality on the 1002 area could occur as a result of hunting or accidental death, especially collisions with vehicles. Because so few moose use the area and because of the area's open nature, the number killed would probably be very low.

Moose populations south of the 1002 area would come under increased hunting pressure due to the influx of workers to the area. Declines in the population age structure and average antler size would probably occur. Moose concentrate in riparian habitats south of the 1002 area where they are highly visible and vulnerable to hunting.

Mitigation

~ Mitigation would include protection of riparian willow habitats, limiting use of transportation corridors and closing the area within 5 miles of project facilities to the discharge of firearms. Moose harvest on the Arctic Refuge is regulated by the State of Alaska in cooperation with the FWS, and could be kept within sustainable limits by modifying harvest seasons and bag limits. ~

Conclusion

Effects on the regional moose population from habitat loss and mortality due to oil development would be minor.

DALL SHEEP

Dall sheep are rarely found north of the Sadlerochit Mountains, although they are common in the Brooks Range, south of the 1002 area. Increased hunting pressure, air traffic, and harassment by sightseers could cause some indirect adverse effects to Dall sheep.

Mitigation

More restrictive hunting regulations could be required if increased harvest affects the health of Dall sheep populations or reduces the quality of hunting and associated recreational use.

Conclusion

Indirect effects on sheep outside the 1002 area would be minor. Full leasing would have a negligible effect on Dall sheep in the 1002 area; average age and, consequently, horn size of rams may decline somewhat as hunting pressure increases.

WOLVES

Five to ten wolves seasonally use the 1002 area (Weiler and others, 1985), mainly in the summer for hunting when prey is most abundant. Wolf dens have not been documented. Wolves have denned infrequently on the coastal plain east and west of the 1002 area. Although wolves occur throughout the Arctic Refuge, total numbers for the refuge are not known.

The effects of direct habitat loss to wolves would be negligible. Reduction of prey species (primarily caribou) caused by oil development could reduce wolf vigor and, consequently, productivity. The abundance of wolves is ultimately determined by the biomass of ungulate prey (Keith, 1983). Harrington and others (1983) reported a positive correlation between prey availability and survival of young wolves. Ability of adults to readily provide food is a key determinant in wolf-pup survival (Van Ballenberghe and Mech, 1975). Reduction of prey species would be greatest in the area east of the Hulahula River where caribou activity and, consequently, wolf use have been the greatest.

Development activity is not expected to cause wolves to avoid the area. During construction of the Dalton Highway and TAPS, instances of wolves becoming habituated to human activity were recorded. In some cases, wolves readily accepted handouts from construction workers (Eberhardt, 1977; Follmann and others, 1980).

Shooting or trapping, which may be the most likely causes of direct mortality to wolves, could increase with increased human access. Zimen and Boitani (1979) and Mech (1970) reviewed the drastic reduction of the former range of wolves, not just in North America but throughout the Northern Hemisphere. The decline in wolves has largely been a result of human effort to reduce wolf populations.

Mitigation

Measures designed for prey species such as caribou will also help reduce adverse effects to wolves. Enforcement of existing regulations by the State and the FWS would reduce potential effects of hunting. A few wolves might be killed for public safety (to combat rabies), with a minor effect on the population. Strict enforcement of prohibitions against feeding wildlife and providing adequate garbage handling would prevent wolves from becoming nuisances around camps, decreasing the probability of these animals being shot or trapped.

Conclusion

A moderate decline of the wolf population using the 1002 and surrounding area could result from the cumulative effects of direct mortality and reduced production or survival of young caused by reduced prey availability.

ARCTIC FOXES

Arctic foxes are common and widespread on and around coastal areas. Winter fox habitat is primarily along the coast and on the sea ice outside the 1002 area; denning occurs up to 15 miles inland. Habitat loss associated with oil development would be negligible. Experience on the North Slope has demonstrated that foxes are not greatly displaced. One fox den was reported abandoned when a seismic camp parked next to it (Eberhardt, 1977), but foxes readily used culverts and other construction materials around active TAPS construction camp sites for denning.

Direct mortality as a result of shooting and trapping would cause a minor population reduction. Regulations would limit most of this effect. Some foxes would be shot for public safety reasons (rabies). Once habituated to people, foxes become very bold which may increase their vulnerability to shooting or trapping. Accidents such as road kills would annually claim a few individuals. Improper garbage handling and illegal feeding of foxes could provide an unnatural supplementary food source which could enhance overwinter survival and production of young.

Arctic foxes regularly fed in dumps around construction camps during construction of TAPS (Eberhardt, 1977). Foxes have high fecundity rates which are directly influenced by food availability. MacPherson (1969) reported an average litter size of 10.6 at Demarcation Bay. Under natural conditions production and survival of arctic foxes are directly linked to oscillations in rodent abundance (Speller, 1972). Consequently, arctic fox populations can increase rapidly when rodents are abundant. The effect of increased artificial feeding may result in increased density and, subsequently, increased exposure to rabies and other diseases.

Mitigation

No mitigation beyond that already outlined for other species is recommended.

Conclusion

The effects on the arctic fox population are uncertain. Population could increase because of the potential for increased artificial food supplies, or decrease as a result of direct mortality from shooting, accidents, or rabies. Any effect is expected to be minor.

WOLVERINES

The wolverine population is scattered throughout the 1002 area at low density (Mauer, 1985a). Recent wolverine observations on the 1002 area (Mauer, 1985a) relative to levels reported at other sites on the North Slope (Magoun, 1979) suggest that current 1002 area wolverine numbers may be at a low level in relationship to habitat quality. Data regarding wolverine use at specific locations within the 1002 area are lacking as are population estimates for the entire Arctic Refuge.

Throughout their circumpolar distribution, wolverines occur exclusively in remote regions where human activity is low (van Zyll de Jong, 1975; Myhre, 1967). The wolverine has been displaced from southern portions of its historic range in Eurasia and North America (Myhre, 1967) and is known to be cautious and wary of humans (Krott, 1960). Wolverine distributions and movements would be altered by the presence of human activity associated with oil development. Displacement of wolverines from local areas of development is very likely. In considering potential population effects on wolverines by the proposed Susitna hydroelectric project, Whitman and Ballard (1984) thought that local avoidance of work camps would not significantly influence wolverine movements or productivity.

Because wolverines are primarily scavengers, their abundance is related to the biomass and turnover of large herbivore populations (van Zyll de Jong, 1975). Thus, the magnitude of anticipated effects on populations of caribou, muskox, and moose upon which wolverines depend will directly affect the degree of effects on wolverines. Major effects have been projected for caribou and muskox

populations, minor effects for moose. Magoun (1985) stated that successful management of wolverines in Game Management Unit 26A on the North Slope was directly related to successful management of the Western Arctic and Teshekpuk Lake caribou herds. She further stated that a decline in these herds could result in a decline in wolverine productivity. Whitman and Ballard (1984) believed that a decrease in the populations of moose and other prey as a result of the proposed Susitna hydroelectric project could eventually affect wolverine densities, population size, and movements. Reduction in abundance of the primary predators (wolves and brown bears, for which moderate and minor effects are predicted, respectively) could also decrease the abundance of prey carcasses available for scavenging by wolverines.

~ During the winter, wolverines on the tundra are vulnerable to hunting from snowmobiles and aircraft. Increased hunting and trapping could occur as a result of the greatly improved access provided by the roads, trails, and airstrips associated with oil and gas development, and the increased human populations in the region. Van Zyll de Jong (1975) felt that human predation was the factor most likely to affect wolverine numbers. ~

Mitigation

Measures designed for prey species such as caribou, muskox, and moose will also benefit wolverines. Control of access and harvest to minimize direct mortality would be the most important determinant of effects. This control is recommended as mitigation for effects on several species.

Conclusion

The cumulative effects of displacement, avoidance, and reduced food resources could result in localized, long-term changes (a moderate effect) in wolverine distribution. Inadequate controls on access and harvest could possibly reduce by half or more the 1002 area wolverine population. If this occurred, it could result in a major effect on that population.

BROWN BEARS

Brown bears are common on the 1002 area during May-September when they forage and range widely. The 1002 area contains habitat used seasonally by bears at moderate or high density (pl. 1D). Habitat use and populations throughout the Arctic Refuge have not been similarly delineated.

Under full leasing, direct loss of brown bear habitat would total about 3,500 acres. Oil-field activities would take place throughout approximately 17 percent of brown bear high- and moderate- use areas. Quantifying the number of animals involved is difficult. Seasonal density averages one bear/30 square miles, but local densities can range from one bear/18.5 square miles to one bear/2,200 square miles.

Brown bears use the 1002 area mainly for feeding from late May through July when caribou are present. The potential decline in caribou population and change in distribution probable with full leasing (major for the PCH and moderate for the CAH) could cause a decline in an important food source for brown bears. This could result in decreased bear productivity and survival of young in years when alternate food sources, such as rodents, are scarce.

Brown bears are not readily displaced by human presence or activity. Brown bears along the TAPS corridor became so habituated to development that they occasionally entered occupied buildings in search of food (Follmann and others, 1980), routinely fed at garbage dumps, and waited along roads and other areas for handouts. Electrified fencing successfully eliminated problems with both brown and black bears in two summer camps of 100 people each in the Brooks Range (Follmann and Hechtel, 1983).

~ Disturbance to brown bears denning on the 1002 area could occur, particularly from winter seismic exploration because such activity occurs after brown bears have denned and den sites may not be known. Disturbance of denning bears, once development is complete, should be negligible because bears would likely avoid denning in areas where activity was occurring. Reynolds and others (1983) found that radio-collared brown bears in their dens were disturbed by seismic vehicles or shot detonation 1.2 miles away, as demonstrated by increased heart rate and movement within the den, but no negative effect such as den abandonment was documented. Harding and Nagy (1980) reported brown bears successfully wintering within 1 to 4 miles of oil exploration camps. Conversely, they reported a den being abandoned when a seismic vehicle drove over it, and also den destruction during gravel mining. Quimby (1974) reported that 5 of 10 brown bears apparently abandoned dens in early October after being followed to their dens by helicopters. ~

~ Only 7 of 149 (3.5 percent) den sites documented during the Arctic Refuge baseline studies were located on the 1002 area (Garner and others, 1984, 1985). Therefore, the potential to disturb denning habitat and disrupt denning activities of the regional brown bear population by oil exploration and development would be low, and impacts would be expected to be minor. ~

Aircraft disturbance of bears is unavoidable. Doll and others (1974) and McCourt and others (1974) reported variable reactions by bears to aircraft disturbance at 1,000 feet AGL or less. Douglass and others (1980) reported bears reacted strongly to hazing by vehicles and aircraft.

~ Direct bear mortalities will occur from accidents or their being shot in defense of human life and property. Drug-induced death of bears occasionally occurs when nuisance bears are immobilized for relocation. Accidents, such as collisions with vehicles, could also reduce bear

numbers. Follmann and others (1980) reported 13 brown bears killed in conjunction with TAPS construction and operation during 1971-79. The BLM (1983) estimated that oil development on the NPRA in an area having a bear density similar to that of the 1002 area would produce a loss of approximately one bear annually as a result of confrontation between bears and oil-development personnel. The rate of mortality would presumably be similar on the 1002 area. Most deaths would probably result from bears' being attracted by improper garbage or food handling, or illegal feeding. ~

Bears that seasonally use the 1002 area are part of the same regional population inhabiting the mountains and foothills of the Brooks Range. Hunting pressure on this population could increase if oil workers remained on the 1002 area during off-duty periods to pursue recreational activities. Increased harvest of bears occurred during construction of TAPS (Follmann and Hechtel, 1983). Schallenberger (1980) similarly reported an increase in bear harvest as a result of increased human presence associated with oil development. Further regulation of hunting by the State and the FWS would probably be required.

Mitigation

In addition to those measures listed earlier in the chapter, strict enforcement of prohibitions on feeding wildlife, adequate food storage, control of harvest, and control of aircraft flight altitudes and corridors would lessen adverse effects of development resulting from full leasing. An active program monitoring brown bears during seismic exploration, construction, and other development would help avoid disturbance of denning bears. Buffer zones of at least 1/2 mile would be established around any known dens as required for previous exploration (50 CFR 37.32 (c)).

Conclusion

A moderate decline in number or change in distribution of brown bears using the 1002 area could result from the additive effects of direct mortality, decreased prey availability, harassment, and disturbance in denning areas.

ARCTIC GROUND SQUIRRELS AND OTHER RODENTS

Arctic ground squirrels are commonly found throughout much of the 1002 area. Moderate effects would result from localized habitat alterations such as placement of gravel pads over squirrel colonies. Minor effects would be expected from road kills.

Other rodents, primarily lemmings and voles, are naturally cyclic in abundance but can be affected somewhat by development. Some effects may be positive--structures and debris would provide protective cover from hawks, owls, or other predators. Negative effects could include localized destruction of nesting sites and increased mortalities from entrapment and traffic.

Mitigation

No additional measures are recommended.

Conclusion

Developing oil resources throughout the 1002 area would cause minor to moderate effects on squirrel populations because of habitat loss and alteration. Effects on lemmings and voles should be minor.

MARINE MAMMALS

Fourteen species of marine mammals may occur off the coast of the Arctic Refuge. The five species most common to the coastal plain or nearshore area were evaluated: polar bear, ringed and bearded seals, and beluga and bowhead whales.

POLAR BEARS

Polar bears are one of the few large mammal species present on the 1002 area during winter.

~ Polar bears are particularly sensitive to human activities during the denning period. Belikov (1976) reported that females will usually abandon their dens prematurely if disturbed. Early den abandonment can be fatal to cubs unable to fend for themselves or travel with their mother. Development of potential petroleum prospects in Block C could have a moderate adverse effect on the continued suitability of the eastern portion of the 1002 area for denning polar bears, substantially decreasing the habitat values. Between 1951 and 1987, 16 maternity dens were found on land within the 1002 area and 3 confirmed dens and 2 possible dens have been found just north of the study area on the shorefast ice (pl. 1E). ~

Factors that may influence responses of denning female polar bears to disturbance include frequency and level of disturbance, distance of disturbance from the den, and stage of denning at time of disturbance. Pregnant females beginning to den in the fall are especially vulnerable. A radio-collared female polar bear denning in the 1002 area emerged from her den in early February 1985 (Amstrup, 1986), the suspected result of repeated disturbance by motorized exploration support equipment within 1,600 feet of the den site. The bear was suspected of being pregnant when she entered her den in December.

Pipelines and roadways may prevent female polar bears from moving to and from inland denning areas (Amstrup and others, 1986; Lentfer and Hensel, 1980). Disturbance by oil exploration, construction, and production in the immediate vicinity of polar bear dens could cause the bears to abandon dens. Production activities could create disturbances that would likely keep bears from returning to those preferred denning areas.

~ Development and production facilities in confirmed coastal denning areas could produce a major reduction in the availability of denning habitat. Although the number of bears returning each year varies depending on ice, snow, and weather conditions, some researchers believe female polar bears show fidelity to birth sites and try to reach areas previously used for denning (Lentfer and Hensel, 1980). Recent analyses suggest that mortalities of female polar bears are now about the maximum the Beaufort Sea population can sustain (Amstrup and others, 1986) without a decrease in population levels. Thus, undisturbed onshore denning habitat is important for the 12 to 15 percent of females denning on land. Moreover, the coastal land of the 1002 area and the refuge lands to the east are especially significant areas for denning on land in Alaska (U.S. Fish and Wildlife Service, unpublished data). ~

~ Additional losses and reduction of habitat value would result from development of marine facilities. The potential Pokok port site would be in a confirmed coastal denning area; polar bears were known to have denned within approximately 1 mile of the potential site for at least 3 years. The Camden Bay area has also been used by denning polar bears; one radio-collared bear denned there in 1986-87. The cumulative effects of additional human activity levels and expansion of facilities offshore or other potential developments could result in changes in bear distribution and prey distribution. Possible contamination of prey species (due to such things as a catastrophic oil spill) could further reduce habitat values in the 1002 and offshore areas. ~

The effects of oil development on nondenning segments of polar bear populations are not well known. These segments generally inhabit pack ice throughout the year, although in the fall a number of animals, primarily family groups composed of females and juveniles, are seen along the coast (Amstrup and others, 1986). Potential adverse effects on bears inhabiting pack ice could be caused by shipping traffic and concomitant disturbance of water and ice, or by an accidental oil spill from a ship or loading facility.

Disturbance alone may not greatly affect nondenning bears. Direct effects of oil contamination are not well known. Initial results of a study conducted in Canada (Hurst and others, 1982) indicate that bears forced to enter an oil slick and then subjected to cold temperatures and wind will die; that study did not determine if polar bears will voluntarily enter an oil slick.

Polar bears are attracted by garbage dumps and could become a nuisance or threat to personnel in camps. Because bears are sometimes attracted to the Barter Island area to scavenge on whale carcasses, nearby oil facilities could experience a higher occurrence of nuisance bears than other facilities report.

~ Mitigation ~

Some adverse effects on polar bears could be reduced by documenting den locations and use areas so that oil-development activities avoid them to the maximum extent possible. Avoidance of suitable denning habitat is most important. To prevent disturbance which could cause early den abandonment, buffer zones of at least 1/2 mile should be established around known dens, such as the zones described for brown bears (50 CFR 37.32 (c)). Conflicts with bears that do den on the 1002 area along the coast could be minimized by limiting construction activities during the denning period. Where possible, orienting seismic lines, pipelines, and roads at right angles to the coast in coastal areas could further minimize interference with bears coming ashore to den. Also, ice quality and movement data collected by industry should be made available to the FWS to augment research attempts to understand polar bear movements and behavior. Such data would be invaluable in learning how to predict and minimize adverse effects of industrial activities on polar bears.

If attracted by garbage, polar bears could become a nuisance or threat to personnel and would need to be relocated. Proper garbage control and fencing of camps would reduce this problem. Except for purposes of scientific research or other authorized takings, such as by Alaskan Natives, nuisance bears would have to be trapped and relocated as required by the Marine Mammal Protection Act of 1972. The exception would be extreme situations where other methods of humane taking are necessary for either the welfare of the animal or protection of the public health and welfare.

~ Conclusion ~

Recent studies of radio-collared female polar bears have documented the consistent use of the 1002 area for denning. However, they do not indicate the full extent of denning in this area because radio-collared bears constitute approximately 5-20 percent of the denning segment of the Beaufort Sea polar bear population. Exclusion of these bears from areas consistently used for denning would have a moderate impact on that segment of the Beaufort Sea population because some decline in the reproduction rate could result. Given the apparently stable Beaufort Sea population of approximately 1,300-2,500 polar bears, such exclusion and decline in natality would likely not affect the species' overall survival, so long as similar intensive developments did not occur along the entire northern coast of Alaska and Canada. However, the cumulative effects of such potential developments are a concern with the population. Biologists believe that the Beaufort Sea population can sustain little, if any, increase in mortality of females because population surveys and calculations show that the number of animals dying each year is approximately equal to the population increase from reproduction (Amstrup and others, 1986).

SEALS AND WHALES

Oil-development activities having the greatest potential for affecting seals and whales would be those occurring along the immediate coast or just offshore. Under full leasing any oil development and production would probably occur far enough inland to have no direct effect on either seals or whales. Marine and air support facilities could affect some marine mammals, because noise-producing activities generally disturb marine mammals.

Major sources of noise are low-flying aircraft or equipment that produces high-frequency, high-pitched sounds. Low-flying aircraft are known to panic hauled-out seals. If the disturbance is frequent during molting, successful regrowth of skin and hair cells can be retarded, increasing physiological stress on seals during a normally stressful period (U.S. Minerals Management Service, 1984). Another source of noise is vehicular traffic on coastal ice roads, of concern because noise transmitted through the ice may be loud enough to displace denning and pupping ringed seals to a degree sufficient to reduce reproductive success (U.S. Minerals Management Service, 1984). Underwater noise from boats and from aircraft flying at altitudes of less than 2,000 feet has been recorded (Fraker and Richardson, 1980; Greene, 1982; Ford, 1977; Fraker and others, 1981). Such noise may disturb or alarm marine mammals, causing them to flee.

Fraker and others (1978) reported a startle response by beluga whales and flight from barges and boats traveling through a whale concentration area. Flight or avoidance could displace whales from important habitat areas. However, monitoring of beluga behavior and distribution for 10 years did not show any long-term or permanent displacement of whales from Mackenzie Delta development areas (Fraker, 1982).

Vessel operations (boats, barges, icebreakers) would increase with development of marine facilities at either Camden Bay or Pokok. Associated noise and disturbance would be the activity most likely to affect bowhead whales in the area. Preliminary field experiments on bowhead whales showed statistically significant differences in behavior as a result of nearby boat activity, including decreased time spent at the surface, decreased number of blows per surfacing, increased spreading out of grouped animals, and significant changes in direction of movement (Fraker and others, 1981). Bowheads in summer feeding areas have been observed to move away from boats when approached to within 0.6 mile, and sometimes to within 1.9 miles (Fraker and others, 1982). There was no evidence that bowheads abandoned any area where they have been disturbed by a boat; their flight responses seemed to be brief. Whether frequent or continuous boat operations would ultimately cause bowheads to vacate an area or would lower their reproductive fitness is unknown (Fraker and others, 1982). Conclusive evidence of effects of boat traffic on bowhead migration patterns or behavior during migration does not exist. East of Barrow, traditional spring

migration of bowheads is seaward from the coastline. If icebreaking vessels are used to supply 1002 area development needs, artificial leads may be created. These leads could alter migration chronology, encouraging early movement into northerly areas before safe open-water conditions exist.

Short-term behavioral modification could occur near proposed marine facilities: changes in migrational routing, decreased time spent at the surface, concentration or dispersion of aggregations, or changes in swimming speeds. These changes would probably not preclude successful migration. But, the ultimate effect of disturbance may be abandonment of a particular area, and possibly reduced productivity and population size. Long-term behavioral effects from noise and vessel disturbance have not been demonstrated or measured.

Dredging or gravel deposition during construction could affect marine mammals through disturbance, habitat alterations, and changes in availability of food sources. Noise and other disturbances by dredging, causeway construction, and support traffic could displace marine mammals up to approximately 2 miles from the activity site during operations (U.S. Minerals Management Service, 1983). Dredging could also temporarily disrupt or remove prey species for several miles downstream from dredging sites, as could gravel deposition near the port construction sites. Short-term, site-specific increases in turbidity in the coastal area would not adversely affect seals, whales, or their habitats. Sediments associated with causeway construction would be less than, but additional to, that naturally occurring during spring breakup or storms (Lowry and Frost, 1981).

Mitigation

No mitigation beyond that already outlined for other species is recommended.

Conclusion

The continued presence of dolphins, porpoises, and seals in coastal marine habitats having high levels of industrial activity and continuous marine traffic strongly suggests that at least some marine mammals are able to adjust to manmade noise and disturbance (U.S. Minerals Management Service, 1984). Knowledge of marine mammal behavior associated with industrial disturbance elsewhere suggests that any behavioral changes in animals using the Arctic coast would be minor as a result of petroleum development.

BIRDS

Factors that may directly affect birds using the 1002 area include shoreline alteration; facility siting; gravel mining; dredge and fill operations; contaminants from reserve pits, drill muds, and fluids; pipeline and road construction; and associated developments. The responses of birds to

human disturbances such as road traffic, aircraft flights, and other development-related activities are highly variable and depend on factors such as species; physiological or reproductive state; season; distance from disturbance; and type, intensity, and duration of disturbance.

Adverse effects of further exploration on birds are likely to be minor. Habitat modification and disturbance will have their greatest effect during oil-field development and production. Of primary concern would be permanent habitat loss from facility sitings, roads, and pipelines. Approximately 5,650 acres of tundra habitat would be destroyed and at least an additional 7,000 acres would be modified due to dust and gravel spray, different rates of snowmelt, and changes in water drainage. Effects of habitat modification and disturbance are discussed in terms of the five bird categories used in Chapter II: swans, geese, and ducks; seabirds and shorebirds; raptors; ptarmigan; and passerines.

SWANS, GEESE, AND DUCKS

Disturbance associated with exploration and development, especially from air traffic near nesting waterfowl, could reduce productivity of waterfowl and may cause abandonment of important nesting, feeding, and staging areas. Studies in the Arctic indicate that black brant and common eider had lower nesting success in disturbed areas (Gollop, Davis, and others, 1974). Schweinsburg (1972) reported that snow geese were particularly sensitive to aircraft disturbance during pre-migratory staging. Conversely, studies by Ward and Sharp (1973) and Gollop, Goldsberry, and Davis (1974) indicate the unlikelihood of long-term displacement or abandonment by oldsquaw of important molting and feeding areas as a result of occasional aircraft disturbance. Recent work near Prudhoe Bay has shown increased habitat use by northern pintails in impoundments near roads (Troy and others, 1983; Troy, 1984).

A small increase in direct waterfowl mortality would be possible. Road kills of hens and flightless broods could occur, as well as some aircraft-bird collisions. Several investigators (Sopuck and others, 1979; Blokpoel and Hatch, 1976; Cornwell and Hackbaum, 1971; Anderson, 1978) have reported mortalities when waterfowl strike manmade objects, particularly powerlines. Some poaching could also occur.

Nest predation appears to be a significant source of natural mortality for waterbirds on the North Slope. Should raven, gull, or arctic fox populations increase as a result of poor housekeeping practices at facility sites (uncontrolled garbage dumps or feeding), predation on waterfowl nests and young could increase. Wright and Fancy (1980), studying the effects of an exploratory drilling operation at Point Thomson, Alaska, found that a large proportion of waterfowl nests were lost to predators at both the drill site and the control area. At least 50 percent of loon clutches failed prior to hatching and five of eight waterfowl clutches

were taken by predators, mostly arctic foxes. Disturbance that causes adults to temporarily abandon their nest or young can also increase predation.

Oil and other contaminant spills could kill waterfowl, particularly in lagoons where waterfowl congregate in large numbers. The effect on 1002 area populations could be major if a spill occurred in lagoons during peak molting, staging, or migration periods. Effects could also extend to other bird populations which migrate along the Arctic Refuge coast.

The alteration of habitat and food chains by oil or other contaminant spills may affect birds through direct ingestion or contact. These effects are apt to be more subtle and prolonged. Because most breeding and many nonbreeding birds depend on invertebrate food sources during at least a portion of their stay on the North Slope, pollution-induced depression of invertebrate populations may influence survival and reproduction.

Oil spills can affect invertebrates through direct mortality by smothering, contact toxicity, toxicity of soluble compounds, and destruction of sensitive eggs and larvae. Spills can also have sublethal effects such as destruction of food sources, reduced tolerance to stress, interference with behavioral and integrative mechanisms, and concentration of carcinogens or other toxic compounds in the food chain (Percy and Mullin, 1975). A closer examination of sublethal effects upon physiological functioning shows that over an extended period such effects may cause death of an organism. Mortality may result from a combination of behavioral and physiological disfunction, reduced feeding and stress, increased predation, and long-term increases in metabolic rate (Percy and Mullin, 1975).

In their study of major oil spills, Teal and Howarth (1984) concluded that the effect on aquatic invertebrates ranged from massive kills and total eradication of microbenthos communities to elimination of only the sensitive species. Effects on phytoplankton populations included changes in species dominance, depression of biomass, or increased biomass brought about by the reduction of zooplankton grazers. In some cases, invertebrate populations were still depressed 6 to 7 years after the spill. In other spills, recovery occurred within a year. Recovery of aquatic systems in Arctic waters would be much slower (Percy and Mullin, 1975).

An experimental spill of Prudhoe Bay crude oil on a tundra pond by Barsdale and others (1980) eliminated several invertebrate species from the pond for at least 6 years. These included fresh-water aquatic invertebrates utilized by breeding tundra birds.

The effect on North Slope bird populations from changes in water quality of tundra ponds as a result of reserve pit discharges has not been studied. But, along

with deteriorations in water quality, the quality and quantity of aquatic organisms used as food by waterfowl may be considered as also decreasing, thereby reducing habitat values (R. L. West and E. Snyder-Conn, unpublished data).

Sources of direct waterfowl mortality would include: shooting; strikes with towers, transmission lines, antennas, and other structures (particularly during the frequent foggy weather); predation; and environmental contaminants. The annual loss would be highly variable, depending on the number of waterfowl using the area and weather.

Tundra swans concentrate in the 1002 area in the Canning-Tamayariak delta, Hulahula-Okpilak delta, Aichilik-Egaksrak-Kongakut delta, and Jago River wetlands (Brackney and others, 1985a). Up to 100 nests have been found, and 280 to 485 swans have used the Arctic Refuge coastal plain; most of this use is on the 1002 area.

Direct loss of tundra swan habitat would be relatively limited (pl. 3A). An area of low-density swan use could be affected by development in Block C. Marine facilities at Camden Bay or Pokok would also adversely affect swan habitat. Transportation corridors would have little effect on tundra swan nesting and staging areas, because they are positioned away from coastal areas where most nesting occurs. Repeated disturbance by air or surface traffic, or by other activities associated with development, might cause nest abandonment where nests and those activities occur in the same area. Nevertheless, swan nests and use areas have been observed less than 2 miles from the village of Kaktovik (Brackney and others, 1985).

Snow geese would directly lose more than 2,900 acres of their historically used staging habitat in Blocks B, C, and D (pl. 3B) as a result of facilities placement and infrastructure. Nearly 2,000 acres of this is considered preferred staging habitat used by approximately 75 percent of the snow geese that use the 1002 area in any given year. Because this habitat represents less than 1 percent of the total preferred staging habitat available in the 1002 area, this direct loss of habitat would result in minor effects.

Disturbance which would result in indirect habitat loss could have a greater effect on snow geese. They are highly sensitive to aircraft disturbance. Investigations in northeast Alaska and northwest Canada reported that snow geese flush in response to fixed-wing aircraft and helicopters passing by at 100-10,000 feet AGL and distances of 0.5 to 9 miles away (Salter and Davis, 1974; Davis and Wiseley, 1974; Barry and Spencer, 1976; Spindler, 1984). Spindler (1984) found that fixed-wing aircraft flying at low altitudes produced less disturbance than at higher altitudes. He attributed this to reduced lateral dispersion of sound. Davis and Wiseley (1974) reported limited habituation to aircraft disturbance; flushing distance decreased after several passes by a helicopter. Flight distance of the geese decreased after several passes of a fixed-wing aircraft.

Disturbance by vehicle traffic, drilling, human presence, or other causes could extend up to 3 miles from the source. Gollop and Davis (1974) reported that the noise from a gas-compressor-simulator disturbed staging snow geese 3 miles away from the source at Komakuk Beach, Yukon Territory. Some birds eventually returned to within 1.5 miles of the noise. Wiseley (1974) reported similar noise disturbance which displaced snow geese within 0.5 mile. Hampton and Joyce (1985) reported that snow geese were disturbed by general activity associated with oil development at Prudhoe Bay. Wiseley (1974) did report limited habituation to disturbance over time.

Existing data on the degree of displacement are inconclusive. Table VI-7 shows the amount of habitat that could be affected by development resulting from full leasing, assuming snow geese are displaced 1.5 and 3 miles as observed by Gollop and Davis (1974). With an assumed 3-mile displacement, habitat values could be reduced on as much as 45 percent of the preferred staging area on the 1002 area and 27 percent of the total preferred staging area in the Arctic Refuge. A 1.5-mile displacement would result in reduced habitat values on nearly 31 percent of the preferred staging area within the 1002 area and up to 18 percent of the total preferred staging area within the Arctic Refuge.

~ An average of 105,000 snow geese stage on the 1002 area (22 percent of the Western Arctic population), building energy reserves prior to their southward migration. As many as 326,000 snow geese have staged on the 1002 area and adjacent Wilderness coastal plain. Patterson (1974) reported an increase of 7.2 ounces of fat and 1.7 ounces of muscle (wet weight) in juvenile snow geese while they were on the 1002 area. Brackney and others (1987) found an average daily gain of 0.7 ounce of fat (dry weight) for adult snow geese and 0.35 ounce/day for juveniles. Reduced time spent feeding and lost habitat in which to feed would result from petroleum development, adversely affecting accumulation of the energy reserves essential for migration. Davis and Wiseley (1974) estimated that staging juvenile snow geese unable to adjust to aircraft disturbance accumulated 20.4 percent less energy reserves as a result of lost feeding time. Energy reductions of this magnitude could reduce the survival of migrating geese. ~

Mitigation

Measures outlined for other species also apply to waterfowl: careful facilities siting and controls on surface activities, air transportation, and hunting. Reserve pit fluid discharges and other contaminants should be adequately controlled. Powerlines should be designed to minimize losses from bird strikes by burying, attaching to pipelines, or otherwise eliminating the need for poles. Increased hunting by workers in the area will occur but will be kept to a minimum level by the assumed prohibition of firearms discharge around development areas. The judicious placement of transportation corridors south of coastal nesting areas would be particularly important for tundra swans.

Conclusion

A decline in waterfowl use could occur. Indirect mortality would result from the cumulative loss of nesting and feeding habitat, persistent disturbance by development activities, and spills or contaminants from reserve pits and other facilities. Direct mortality from road kills, aircraft, bird collisions with structures, and poaching is expected to be minor. With effective implementation of mitigation and use of knowledge gained during previous oil development on the North Slope, the overall effect is expected to be minor on ducks, tundra swans, and geese other than snow geese. Operational needs, weather, and safety of personnel and equipment may limit the effectiveness of aircraft altitude and corridor restrictions as well as some time and area closures.

A moderate reduction or change in distribution of snow geese using the 1002 area could occur through the cumulative effects of direct habitat loss, indirect habitat loss

due to disturbance, and direct mortality. Disturbance will cause subsequent loss of feeding areas and feeding time, as well as energy drain, and would be the single largest negative force causing losses in habitat value. This is based upon historical use of the 1002 area by some of the Western Arctic snow goose population and the assumed 1.5 mile displacement of these geese from 31 percent of their preferred staging habitat. Maximum displacement (3-mile influence) could be as much as 45 percent. An average 5-10 percent change in distribution could occur. Because annual use of the 1002 area is highly variable, actual effects could vary widely from year to year.

SEABIRDS AND SHOREBIRDS

Development would have widely varying effects on seabird and shorebird species, depending on time of year, location, and type and intensity of disturbance. Nesting seabirds are likely to be more susceptible to development

Table VI-7.--Snow goose staging habitat potentially affected by development under full leasing or limited leasing, assuming 1.5- and 3-mile spheres of influence. (Gollop and Davis, 1974)

[Preferred staging is defined herein as the area used by approximately 75 percent of the staging snow geese on the refuge in any given year. Peripheral staging is defined herein as the area used by staging snow geese, excluding the preferred staging area.]

	Preferred staging	Peripheral staging	Total staging area
Staging habitat within the Arctic Refuge (acres)	888,000	460,000	1,348,000
Staging habitat within 1002 area (acres)	529,000	307,000	837,000
Assuming a 1.5-mile sphere of influence:			
Staging habitat affected (acres)			
Full leasing	162,000	101,000	263,000
Limited leasing	95,000	67,000	162,000
Percent of staging habitat within 1002 area			
Full leasing	31	33	31
Limited leasing	18	22	19
Percent of staging habitat within Arctic Refuge			
Full leasing	18	22	20
Limited leasing	11	15	12
Assuming a 3-mile sphere of influence:			
Staging habitat affected (acres)			
Full leasing	236,000	155,000	391,000
Limited leasing	135,000	104,000	239,000
Percent of staging habitat within 1002 area			
Full leasing	45	50	47
Limited leasing	26	34	29
Percent of staging habitat within Arctic Refuge			
Full leasing	27	34	29
Limited leasing	15	23	18

than nonbreeders and can be expected to avoid nesting close to areas having visual or noise disturbances. Nesting attempts in disturbed areas may be less successful, as has been observed with Arctic terns (Gollop, Davis, and others, 1974).

Coastal development sites in Block C and at the Pokok and Camden Bay sites, as well as development inland where gulls, terns, and jaegers often nest, could cause locally moderate effects on some nesting seabird populations. Spilled or leached contaminants from reserve pits or other sources could enter the food chain, reducing invertebrate foods or resulting in accumulation of toxic substances.

~ Population increases in some seabird species can be expected. A certain amount of debris results even from the best of operations. Black guillemots are known to nest in old oil drums and other debris and may respond favorably in some instances if more nesting sites are inadvertently made available. Local glaucous gull numbers could increase considerably around sanitary landfills because of the artificial food source. Over time, other gull species could also be expected to use such areas. Possible long-term increases in gull populations could be moderate to major as a result of increased food. Because gulls eat eggs and young of other birds, a population increase could negatively affect other seabird species. Glaucous gull predation on Canada goose and Pacific brant eggs in the Lisburne oil field was documented by Murphy and others (1986), who noted that predation upon goose eggs may be exacerbated by "an unnaturally high gull population in the Prudhoe Bay area." A nearby open dump is suspected as being the cause of the high gull population. ~

Because of widespread and intensive use of the 1002 area by shorebirds, there is a potential for a variety of adverse effects from petroleum development activities. As with seabirds, these effects include disturbance of nesting birds, ingestion of contaminants, or reduction of food resources because of contaminant spills. Shorebird nesting and staging concentrations occur primarily along the coast and in riparian habitats (pl. 3C). Wet tundra and river deltas are important to migratory and staging birds. Habitats having a good mix of wet and dry terrain are ideal nesting sites for most shorebird species.

~ Recent work near Prudhoe Bay has shown reduced numbers of shorebirds and increased densities of phalaropes near roads in the oil field (Troy and others, 1983; Troy, 1984). Overall diversity of shorebirds was reduced. Direct habitat loss by gravel placement and impoundments as well as effects from dust and noise could occur. Other potential effects, including occasional mortalities from traffic, collisions with towers and communications equipment, and contaminant spills, could occur to a lesser degree. The thaw-lake plains in the lower Okpilak, Jago, and Niguanak River systems are high-use areas that would be affected by development of potentially economic prospects in Block C. Any development on KIC coastal habitats would increase potential negative effects on coastal birds. ~

Mitigation

Careful placement of facilities, restriction of transportation, and control of pollutants would minimize adverse effects on seabirds and shorebirds.

Conclusion

Overall effects on seabird and shorebird populations would be minor if facilities and activities were minimized in the riparian and coastal habitats where nesting and staging are most concentrated. Moderate effects could occur in areas having high seabird and shorebird use where local development is intensive.

RAPTORS

The gently rolling terrain provides limited habitat for cliff-nesting raptor species, primarily where rivers have cut steep banks or exposed rock cliffs. The 1002 area is important foraging habitat for the few cliff-nesting birds of prey that nest there and for those that nest farther south in the foothills and mountains. Short-eared and snowy owls nest in the open tundra and feed throughout the 1002 area and, in years when prey is abundant, owls are common.

Raptors, like most birds, are sensitive to disturbance during their nesting period. If disturbed repeatedly, raptors typically abandon nests. During construction of the Terror Lake hydroelectric project on Kodiak Island in 1983, rough-legged hawks were absent from areas where they had successfully nested in 1980 and 1982 (Zwiefelhofer, 1985). With completion of the dam and elimination of a construction camp in that area, three of four hawk nests were again active in 1984. In contrast, gyrfalcons nested successfully within 1 mile of an airstrip built to support an exploratory well in the NPRA. The nest was occupied during construction activities and was located on the flight path used by approaching aircraft (P. E. Reynolds, unpublished data).

~ Potential conflicts in known high-density raptor nesting habitat used by rough-legged hawks, gyrfalcons, and peregrine falcons (see section on Threatened and Endangered Species) could result from road, collecting-line, and drill-pad systems located in Blocks A and D (pl. 3D). However, the highest density raptor nesting habitat occurs south of the 1002 area and through careful siting of access and development facilities, conflicts would be minor or negligible. Short-eared and snowy owls which nest on the open tundra could experience some reduction of nesting habitat. ~

Once nesting habitat needs are met, raptor populations and distribution vary with prey availability. There would be limited conflict between most raptor nesting habitat and potential development. Adverse effects would be directly related to the adverse effects on the prey base, such as rodents, ptarmigan, and waterfowl. These effects are generally expected to be minor.

~ In 1984, the most common cliff-nesting raptor using the 1002 area was the golden eagle (Amaral, 1985; Mauer, 1985b). Golden eagle distribution appears to be positively correlated with caribou calving and postcalving areas (Mauer, 1985b). The effects on the PCH anticipated from development could result in a change in golden eagle distribution because of decreased numbers of caribou. This effect would be minor because other prey species exist. ~

Direct mortality of raptors resulting from collisions with towers, planes, or electrical wires would be minor.

Mitigation

Measures designed to reduce adverse effects on caribou during calving and postcalving could lessen effects of reduced prey for golden eagles. Siting and designing powerlines and towers to minimize potential strikes, as discussed for waterbirds, will reduce direct mortality to a minor effect. Restricting activities in known high-density nesting areas near Sadlerochit Springs and Bitty Benchmark would further minimize adverse effects of oil development. Specific mitigation measures are listed in the summary at the end of this chapter.

Conclusion

~ The subadult golden eagle population could be expected to change distribution as a result of adverse effects on the PCH, an important prey species. A minor decline in nesting success of other raptors could result from disturbance. ~

PTARMIGAN

Some ptarmigan habitat would be covered by structures and gravel fill. Habitat losses would be most noticeable where facilities were placed in high-use riparian willow areas. Some increase in mortality could be expected from hunting and traffic. Disturbance of nesting or brooding ptarmigan could occur if people or vehicles came too close to nesting birds, scaring off hens or scattering the young flocks. Predators take advantage of such disturbance to prey upon eggs and young. Jaegers have been observed to hover over people hiking across the tundra, waiting for them to flush possible prey (R. L. West, unpublished data).

Mitigation

To minimize habitat losses and disturbance in areas particularly important to ptarmigan, permanent facilities should not be located within a 3/4-mile buffer zone around identified riparian areas, as already recommended for other species.

Conclusion

The effect on rock and willow ptarmigan would be negligible.

PASSERINES

Several passerine, or perching, bird species are found throughout the 1002 area. Riparian willow habitat is used by many passerines for nesting and other activities (pl. 3C). A buffer zone 3/4 mile out from the high-water mark of streams would protect most of the riparian willow habitat. Coastal areas are also important, especially for staging prior to migration. River crossings, marine facilities, and development of economic prospects in Block C could cause minor reductions in habitat availability or suitability, and nesting success of passerines.

Contaminant spills could have major local effects of direct mortality and contamination of foods.

Lapland longspurs are the most common passerine species in the 1002 area. They nest outside riparian zones and are often abundant in a variety of tundra habitats. Most proposed surface development in the 1002 area could be expected to affect some longspur nesting, mainly by covering vegetated habitat with gravel. Only a minor effect is anticipated because of the abundance of the species and its ability to use many common habitat types found in the 1002 area.

Minor to moderate positive effects may occur for two other passerine species. Snow buntings frequently nest in buildings and could find increased nesting opportunities with the construction of oil facilities. Ravens, being scavengers, might find increased food availability around landfills and construction camps, as well as from carrion along roadways.

Mitigation

The 3/4-mile buffer zone for caribou would protect most of the riparian willow habitat important to many passerine species.

Conclusion

Restricting development in riparian areas and controlling contaminants would help minimize negative effects of habitat loss and mortality so that the overall effect would range from a minor adverse effect for most passerines to a minor positive effect on snow bunting and ravens.

FISH

FRESH-WATER FISH

Arctic char are the most-sought-after sport and subsistence fish species in the 1002 area; arctic grayling rank second. Grayling are found in more river systems than char but are in large concentrations at only a few locations. They are not as tolerant of salinity as char and spend most of their lives in fresh water. Other fresh-water

fish (whitefish, burbot, salmon, smelt, and lake trout) are not discussed in detail because they are not common nor taken regularly in the 1002 area by sport or subsistence fishing.

Aspects of oil development that could negatively affect fish are direct mortality or reduced invertebrate food resources resulting from oil or other contaminant spills, failure of sewage and waste-water disposal systems, blasting, and problems from channelization, culverts, and barriers to migration. Increased turbidity from construction and toxic effects of drilling muds could have an adverse effect. Overharvest could result from sportfishing by the large numbers of people brought in to work in the 1002 area.

~ It is likely that the best large fresh-water sources during a development phase would be from large pits excavated in a river flood plain. Such pits would produce gravel and then act as storage reservoirs for water. The 1002 area also contains shallow rivers that do not support significant fish populations. Therefore, there should be no need to disturb critical fish habitat in the construction of the pits. Water withdrawal in critical areas and/or during critical time periods, and gravel removal from fish-bearing stream systems would not be permitted. ~

~ Fish could be swept into storage reservoirs during high river stages, being trapped as stream levels returned to normal or when water is pumped out. The isolation of fish in sloughs and shallow off-stream ponds does occur naturally, however. The reservoirs may ultimately aid fish populations by providing additional overwintering habitat in a region where such habitat is extremely scarce. ~

Individual populations or year classes of anadromous arctic char could be adversely affected over a wide range of fresh-water and brackish-water habitats in which they migrate. Major migration corridors are the Canning and Aichilik Rivers, which form the western and eastern boundaries, respectively, of the 1002 area, and the Hulahula River, roughly midway between them. The Canning River probably has the largest char run; the Hulahula River is likely the greatest contributor to the subsistence catch of char.

Development near any of these three rivers could adversely affect arctic char. The pipeline and haul road would probably cross the Hulahula River to accommodate development in the eastern part of the 1002 area. More than one crossing would increase the potential for adverse effects.

Grayling make extensive migrations to and from spawning, rearing, feeding, and overwintering sites. Major arctic grayling populations are found in the Canning, Tamayariak, Sadlerochit, Hulahula, Okpilak, and Aichilik Rivers (pl. 1B). Because individual river stocks occur, the 1002 area population is vulnerable to impacts over a wide area.

Development of potential prospects and associated transportation corridors in Blocks A and B could create local minor adverse effects on fish populations in the Canning and Tamayariak Rivers. Arctic char, grayling, and other fish use these rivers for spawning, rearing, feeding, and overwintering. Development in Block A would require both water and gravel. If these materials were taken from the Tamayariak River, moderate adverse effects on grayling would result.

The Canning River is the only system in the area known to have other fresh-water species, excluding ninespine sticklebacks which are common in many coastal streams and lakes. Sticklebacks, though having no importance as a sport or subsistence fish, are an important food source for other fish and birds. Culverts and other crossings could strand sticklebacks in areas that do not provide overwintering habitat.

COASTAL FISH

~ There are 62 species of fish that use coastal waters off the 1002 area (Craig, 1984). Docks, causeways, and other facilities at the Camden Bay and Pokok port sites could become physical barriers, causing changes in water chemistry and direct mortality at water-intake structures. Effects on coastal fish could be compounded if offshore and adjacent onshore development occurred, or coastal development near Prudhoe Bay expanded, inasmuch as many anadromous species exhibit major east-west nearshore movements. Oil spills in coastal areas could result in major population reductions depending on the location, time, amount, and type of material spilled. ~

Mitigation

Impacts on fish can be minimized by properly locating and designing road and pipeline crossings and constructing those facilities when fish are not concentrated in the area. Further mitigation should include carefully locating and constructing docks, causeways, and other water-based structures. All feasible methods to maintain water quality and quantity in fish-bearing rivers and streams should be used. Gravel removal and other stream alterations in important fish habitats should be restricted.

Appropriate containment procedures and spill contingency plans for oil and other contaminants will also reduce potential effects by minimizing direct mortality or reductions in invertebrate or aquatic plant food resources. Mitigation measures designed to adequately protect arctic char and arctic grayling will protect other fresh-water species. Proper culverting of road systems will reduce the potential to trap sticklebacks and other fish in areas that do not provide overwintering habitat. Season and creel limits may be adjusted to protect sportfish from overharvest if populations become stressed.

Conclusion

Effects of oil development on arctic char should be minor. Arctic grayling may be moderately affected locally in upper reaches of the Tamayariak River, but would otherwise experience only minor impacts. Effects on other fresh-water fish populations would also be local and minor.

~ The cumulative effects of development of the KIC/ASRC lands or offshore areas could result in moderate effects on coastal fish through lost or reduced habitat values, inhibited movements, and direct mortality. This could have a transboundary effect if impacts affect populations that range into Canadian waters. Development would have minor effects on coastal fish populations near port sites. Elsewhere, the effects on coastal fish will be negligible. If a major oil spill occurs along the coast or in fresh-water fish habitats, the effect on fish could become major. This major effect could adversely affect species that range into Canadian coastal areas, but such a probability would be low. ~

THREATENED AND ENDANGERED SPECIES

BOWHEAD AND GRAY WHALES

See previous discussion under Seals and Whales.

ARCTIC PEREGRINE FALCON

~ Arctic peregrines are absent from the 1002 area from mid-September until April. Oil and gas activities during the summer when peregrines are present could have some minor adverse effects. ~

~ Habitat suitable for cliff-nesting birds of prey is not abundant on the 1002 area. No direct loss or alteration of historic peregrine eyries is anticipated. Formal consultation with the FWS under Section 7 of the Endangered Species Act may be required once a development proposal is prepared. ~

Humans, air traffic, and construction near peregrine eyries may disturb nesting birds. Type, distance, frequency, and intensity of disturbance affect how peregrines react. Frightened adults flushed from an eyrie can injure or kill young. Peregrines may temporarily desert an eyrie after a disturbance, resulting in overcooling, overheating, or excess moisture loss from eggs; chilling, heat prostration, or malnutrition of the young; or predation on both eggs and young (Alaska Peregrine Falcon Recovery Team; Roseneau and others, 1980). Disturbance may also result in premature fledging, causing injury or death of nestlings (Roseneau and others, 1980). The first sites to be deserted in areas studied in Alaska were those eyries closest to human activity (Haugh and Halperin, 1976).

Peregrines could be adversely affected during migration through the 1002 area from late August to mid-September. Their food supply could be reduced if prey

(shorebirds and waterfowl) are displaced or reduced in number as a result of development. Some peregrine mortality might result from collisions with towers, planes, or electrical wires.

Petrochemical or other toxic materials could be accumulated if peregrines ingest prey contaminated as a result of spills or leaks from reserve pits.

Mitigation

Mitigation would include controlling aircraft, noise, surface activities, and other disturbances within 1-2 miles of active nest sites April 15-August 31. Construction of permanent facilities or other long-term habitat alterations (materiel sites, roads, and airstrips) within 1 mile of historic nest sites would require special authorization by the FWS.

Approved handling procedures for chemicals and toxicants will permit few or no adverse effects from contaminants. As discussed for other bird species, transmission lines would be designed to minimize the potential for collisions.

Conclusion

Mitigation will reduce effects on peregrine falcons to minor as concluded in the July 28, 1982, biological opinion appended to the Environmental Impact Statement and regulations for the exploration program in the 1002 area (FEIS, 1983). Protective restrictions (a 2-mile area closure) for the historic nest sites at Sadlerochit Springs and Bitty Benchmark on the Jago River (pl. 3D), and any occupied eyries located through future surveys, should result in only minor adverse effects from disturbance and displacement. Prey reductions are generally expected to be no more than minor. Consequently, no reduction in the peregrine population would be expected. Exploration between June 1 (if a nest remains inactive) or August 31 (if a nest becomes active) and April 15 each year could be allowed with negligible effects on peregrines.

Effects on Human Environment

POPULATION

Oil development in the 1002 area would increase the local population due to an influx of transient workers and support service personnel. Additionally, North Slope Borough job opportunities would probably be created through tax benefits to the Capital Improvement Program as has occurred from Prudhoe Bay development. Many jobs would be generated as a direct result of oil exploration, production, and transportation. Each exploratory and confirmation drilling operation could require 50-75 people during construction of the airfield and drill pad, and 50-60 people during drilling. Drilling during production phases would use slightly smaller construction and drilling crews because much of the needed infrastructure (roads, airfields,

and so forth) would already be in place. Employment levels would be highest during the initial construction. As noted on figure III-1 (see also figure V-I), mapped prospects in the 1002 area may be grouped into three general "regions." During peak construction, an estimated 1,500 people would be employed per region. Operation and maintenance for each region would require 200-500 people. An additional 450-900 people would be employed for 2-3 years to construct the primary road network and pipeline in each region. Rehabilitation could require as many as 1,500 people for several years.

Although highly unlikely, if peak construction occurred throughout the 1002 area at one time, as many as 6,000 jobs (drilling and construction of oil-field and main trunk pipelines) could be created. During the 30-year field life, 200-500 permanent jobs would be located within each prospective oil region, or 600-1,500 permanent jobs in the 1002 area.

The year-round population at Kaktovik would probably not increase dramatically. Most oil-field workers would have permanent residences elsewhere, as do workers at the Prudhoe Bay complex and at military DEW-Line facilities. A few small support industries might locate at Kaktovik, resulting in increased employment opportunities and some small population increases.

Conclusion

Although a major increase in transient population would occur on the 1002 area, only a minor increase in the permanent population at Kaktovik would occur. Elsewhere on the North Slope, and in Fairbanks, Anchorage, or south-central Alaska, the increase would be negligible to minor.

~ SOCIOCULTURAL SYSTEM ~

This full leasing alternative has the greatest potential to affect the sociocultural systems of the area. The number of new residents would increase the most and adverse effects on the subsistence harvest of resources would be the most substantial. Development near subsistence harvest areas may disturb people accustomed to both geographic and cultural isolation. Increased air traffic and human activity are viewed as an aggravation and diminish the esthetic integrity of the harvesting experience.

The economic stimulus from oil and gas activities would increase the importance of cash in the existing mixed economy. This would accelerate the rate of cultural change. The favorable aspects of this impact would be more money available for the villagers to buy items such as guns, snow machines, boats, and fuel. In addition, certain native organizations and public endeavors, such as health and education, could benefit economically. The negative impacts could be unfavorable changes in the villages such as: a diminishing of traditional native culture; an increase in alcoholism, drug abuse and mental illness; and a possible

influx of people, primarily in Kaktovik, who have different value systems. Possibly the most negative cultural impact would be a feeling among villagers of losing control over their lives.

The greatest effects would be on Kaktovik, the village closest to potential development and whose residents most use the 1002 area for subsistence activities (see Subsistence Use section). Some disturbances of subsistence harvest areas, as well as economic benefits, could affect other villages in Alaska and Canada.

Mitigation

Sociocultural impacts are very difficult to mitigate completely, but some steps can be taken to minimize them. The oil industry has developed plans in other areas of the Nation, in conjunction with residents of communities to be affected, to manage developmental impacts in the most desirable manner. An example would be providing chemical dependency and mental illness counseling to individuals. In addition, village and regional entities could be provided with professional guidance for actions to alleviate these problems.

Conclusion

This alternative could have a major affect on the sociocultural system in Kaktovik, and possibly other villages. Activities related to oil development could significantly alter the traditional Native culture. On the other hand development could be viewed as a net economic benefit to the villages.

EXISTING LAND USE

SUBSISTENCE USE

~ Most effects on subsistence are directly related to changes in the availability of subsistence resources. Reductions in fish and wildlife populations, displacement of fish and wildlife from areas of traditional harvest, and reduced access to those resources will adversely affect subsistence uses. Kaktovik would be the village most directly affected. More distant communities whose residents rely on migratory populations of fish and wildlife could be indirectly affected by oil and gas activities on the 1002 area. These include Arctic Village, Alaska, and Old Crow, Yukon Territory, whose residents depend heavily on use of PCH caribou, as well as several other communities in Alaska and the Northwest Territories as discussed in this section. ~

Effects of oil development on fish, wildlife, and their habitats were previously described. The severity of those effects is summarized at the end of this chapter. Resources of greatest concern relative to their importance in local subsistence use and likely severity of adverse effects from full leasing are the PCH and CAH. Waterfowl, fish, whales, and polar bears are also of some concern.

Oil development would reduce access to subsistence harvest areas. The transportation infrastructure could affect the availability of subsistence resources or the ability of local people to reach traditional harvest areas. The presence of several thousand oil-related workers could result in competition for local resources, particularly if any workers become residents of Kaktovik and thus spend more free time in or near the 1002 area. Subsistence hunting would be restricted by safety requirements or for pipeline security. Loss of traditional harvest sites would occur near oil-development facilities or where facilities disturb or displace fish and wildlife resources.

~ Caribou is the staple land mammal in the Kaktovik subsistence diet. They are hunted nearly year-round, with most Kaktovik households participating in the harvest (table II-4). Overall, 83 percent of Kaktovik's 1983-84 caribou harvest was within the 1002 area (Coffing and Pedersen, 1985). Consequently, caribou are of primary concern because of the potential adverse effects on the PCH and CAH anticipated under full leasing. If major changes in caribou distribution or population occurred, it would result in a major restriction of subsistence use for the village of Kaktovik because of the reduced availability of this species at preferred harvest locations, as well as throughout the 1002 area. ~

~ Residents of Arctic Village, Alaska, and Old Crow, Fort McPherson, and Aklavik, Canada, could experience some reduced subsistence harvest as a result of potential effects on PCH caribou distributions or possible population declines. The Canadian communities of Inuvik, Tuktoyaktuk, and Arctic Red River, whose residents occasionally harvest PCH animals, may in some years experience some reduced harvest. ~

~ Decreased opportunities to harvest the CAH would primarily affect Kaktovik, the village closest to the CAH segment which will be adversely affected by oil development. However, residents of Nuiqsut also rely on the CAH for a portion of their harvest and could experience some negative effects. ~

~ Development of any potentially economic prospects found in the Canning River delta within Block A would conflict with a winter and summer harvest area used intensively by Kaktovik residents. Because caribou are likely to reduce their use of traditional calving grounds or their movements may be inhibited by development in Blocks C and D, loss of traditional harvest sites is of significant concern. Any inhibition to free travel during postcalving when caribou move back and forth to insect-relief areas along the coast and forage within the 1002 area could be particularly detrimental, because most subsistence harvest occurs along the coast during July and August. Marine facilities at Camden Bay and Pokok, as well as development of any oil prospects which extend to the coast in Block C, would have the greatest probability of direct conflict with subsistence users. ~

~ The cumulative effects of development offshore or on adjacent KIC/ASRC Lands would present additional conflicts with subsistence users. Those coastal areas have been intensively used for caribou hunting since 1923, and harvest concentrations have been located there in recent years (pl. 2D). Based on the 1981-83 harvests of caribou during July only, the availability of and easy access to the PCH during postcalving may be an important factor in determining annual harvest levels (Pedersen and Coffing, 1984). The July 1981 caribou harvest was three because postcalving caribou were not found close to Kaktovik. But, in 1982, postcalving caribou were numerous along the coast east of the Sadlerochit River and even came onto Barter Island in large numbers; the July harvest then was 82. With postcalving caribou in moderate numbers along the coast east of the Hulahula in 1983, the July harvest was 29. ~

Another potential impact to subsistence is the avoidance of industrialized areas by village hunters. At present, part of the North Slope subsistence hunting range is within the rapidly industrializing central portion of the North Slope. Caribou hunting activity there by Kaktovik residents has declined in recent years. Pedersen and Coffing (1984) suggested that confusion over special harvest regulations associated with the industrialized area, lack of caribou in the area, disruption of access routes, or other reasons may have deterred Kaktovik caribou hunters. Such avoidance could occur on parts of the 1002 area that were developed. Given the nearness and greater use of the 1002 area by Kaktovik residents, such avoidance would severely limit the area and resources available for subsistence harvest.

~ Waterfowl are also harvested by residents of Kaktovik. Effects on major waterfowl species used for subsistence are expected to be minor. Moderate effects on snow geese, a species present during fall staging, are predicted. Due to the difficulty of access to snow geese use areas at that time, and because whaling activities occur then, snow geese are currently not a major component of the subsistence diet. Subsistence harvest of snow geese by communities of the Northwest Territories, however, is substantial. (See Chapter II.) ~

~ Effects of oil development on the Western Arctic snow goose population are expected to be moderate, given the fact that 22 percent of that population stages on the 1002 area. Canadian residents of the Mackenzie Delta communities of Aklavik, Inuvik, Tuktoyaktuk, Panlatok, and Sachs Harbor could experience some negative effects on their harvest of snow geese, but the magnitude of such effects would be speculative. ~

Fishing was pursued by all Kaktovik households surveyed in 1984 (table II-4). Adverse effects on fish could reduce the catch, although those effects would be minor. Locally moderate effects on grayling in the Tamayariak River could result with development in Block A, which is not an important subsistence harvest area. The moderately

negative effect on coastal fish likely if oil is developed on KIC/ASRC lands or offshore areas would be the most noticeable effect on subsistence use of those species. If any oil spills occur, effects on fish taken for subsistence could be major. Even in small quantities, spilled hydrocarbons can taint fish, making them inedible (Crutchfield, 1979).

The overall low level of adverse effects expected on fish suggests minor adverse effects on subsistence uses. However, potential for disturbance of traditional fishing sites exists and access may be modified. The main haul road/pipeline would have to be crossed to reach both Fish hole 1 and Fish hole 2 on the Hulahula River (pl. 1B), which is the most important winter fishing river for Kaktovik residents (Jacobson and Wentworth, 1982). Fish hole 1 is near potentially prospective areas and the airstrip associated with development in Blocks C and D. The access road and pipeline to those areas could cross the Hulahula River near Fish hole 1. Adverse effects would be compounded by increased competition for fish by oil-field workers.

The taking of bowhead whales has been characterized as one of Kaktovik's most important annual activities (Jacobson and Wentworth, 1982), particularly from a cultural standpoint. Subsistence harvest of bowhead whales in Kaktovik and Nuiqsut should not be affected by coastal development, in light of the expected minor adverse effects on whales (in the absence of oil spills). Noticeable effects on villages in Alaska and Canada that take beluga whales are not expected because only minor, local effects on that species are anticipated.

~ Although generally only one or two are taken, polar bears are used by most Kaktovik households because of community sharing of resources. Although the effects of oil development on nondenning segments of the polar bear population are not well known, development may exclude female polar bears from denning in preferred onshore habitats in the eastern and coastal portions of the 1002 area. Consequently there is some potential for a decrease in the availability of polar bears for subsistence harvest in Kaktovik as well as other coastal communities along the North Slope of Alaska and Western Canada whose residents are known to harvest polar bears from the Beaufort Sea stock. ~

Specific subsistence hunting areas vary with season. For example, although inland hunting by Kaktovik residents occurs much less during summer than during winter, subsistence harvest on the coast greatly increases during the summer. Therefore summer operations along the coast could temporarily disrupt subsistence hunting. Development of permanent port facilities and associated access corridors would be a permanent disruption.

Development may physically impact Traditional Land Use Inventory sites of the 1002 area, many of which have values as subsistence use sites for Kaktovik villagers

(Jacobson and Wentworth, 1982). These sites may or may not contain tangible remains, and in many cases their boundaries cannot be easily delimited. Knowledge of an area and how to hunt it are skills gained and passed down through years of experience. These skills cannot be quickly acquired if subsistence users are forced to hunt in new areas. Displacement of subsistence users from traditional use areas is expected to result in a reduced harvest.

A policy that prohibits the discharge of all firearms and hunting and trapping within 5 miles of developments could result in major adverse effects by limiting Kaktovik residents from resources and areas traditionally harvested in over half of the 1002 area. Measures to prohibit off-road vehicle use do not extend to local residents engaging in traditional uses, but subsistence users would not be allowed to use access corridors or aircraft facilities. Consequently, subsistence use will be neither facilitated nor restricted by these measures.

~ Other results of development on Kaktovik subsistence use are more difficult to quantify. Development near subsistence harvest areas may cause people as well as animals to avoid these areas. Noise from airplanes and helicopters flying over and landing in the area could reduce hunting success. Frequent disturbances also cause game to become more wary and more difficult for hunters to approach. ~

In some instances, the impact may be lessened by the availability of alternative resources or harvest areas. Because of the size of the area and number of species which could be affected by full development, alternative subsistence resources and areas for Kaktovik residents may not exist.

Development could substantially increase employment and cash flow in Kaktovik. Therefore, alternatives to subsistence may become available and/or local residents' abilities to purchase equipment for subsistence harvest may increase. Such effects would be unevenly distributed within the community.

Mitigation

~ Measures previously recommended for fish and wildlife and their habitats will also mitigate adverse effects to subsistence harvest by Alaskan and Canadian villages by minimizing the direct loss and displacement of subsistence species. ~

Effects on Kaktovik subsistence uses can further be minimized by facility siting and design. Seasonal closures to prevent wildlife disturbances and other mitigation measures will also minimize adverse effects to subsistence.

Changes in policy regarding access and harvests near development sites would greatly mitigate adverse effects on Kaktovik subsistence uses. If Kaktovik residents

were permitted to use the development infrastructure, including roads and airports, to increase accessibility to subsistence resources, the effect would be positive on their ability to harvest subsistence resources. Excluding development from traditional harvest areas and not restricting local residents' abilities to harvest resources from those areas would minimize adverse effects on continued subsistence use.

Restrictions to subsistence use resulting from reductions in species availability or altered distributions could be offset if access to other areas and resources were allowed.

Conclusion

The cumulative effect of reduced availability of caribou and other subsistence resources through displacement of animals, reductions in populations, lessened access to or closure of traditional harvest areas, and potential psychological effects of development on subsistence practices are considered in determining the impact of development on subsistence.

Effects of further exploration on fish and wildlife are expected to be no greater than minor, including those associated with drilling exploratory wells; therefore, no significant restriction of subsistence uses is likely.

Because oil-development activities throughout the 1002 area could result in major or moderate adverse effects on fish and wildlife resources important to subsistence, as well as on access to those resources, restrictions to subsistence hunting would be expected to occur. Most important would be the possible changes in distribution or risk of declines in population for the PCH and CAH, and resulting effects on communities in Alaska and Canada which depend on harvest of these caribou. Effects on other subsistence use species, disruption of traditional subsistence use sites, and likely psychological effects on people accustomed to isolation will result in a major adverse effect on subsistence lifestyles and a significant restriction on subsistence for the residents of Kaktovik.

~ Competition for resources and the potential for restrictive hunting regulations may add to the severity of impacts on these villagers. The residents of Arctic Village, Alaska, and those in the Canadian villages mentioned should experience only minor restrictions in their use of caribou from the PCH, even if a change in distribution or decline in numbers occurred. Arctic Village and the Canadian villages have traditionally relied on caribou as a staple in their diets, even during years when the PCH population was substantially lower (for example, in 1972 when the herd numbered 101,000) and in years when caribou were either near the villages in reduced numbers or not present at all. Unlike Kaktovik, none of these areas would be subjected to the presence of oil and gas infrastructure, the increase in transient human population, and the other restrictions and disturbances discussed above. ~

~ If the Congress enacts legislation to authorize the Department of the Interior to lease a portion of the 1002 area, then the Secretary of the Interior must, prior to actual lease sales, determine the effects on subsistence of such an action in compliance with section 810 of ANILCA. ~

LAND STATUS AND MILITARY AND INDUSTRIAL USE

Land use on and off Arctic Refuge lands would change, although no change in existing military activities would be expected. Full leasing, however, would eventually introduce industrial development to an area now devoted to Native subsistence, Federal fish and wildlife management activities, and wilderness-oriented recreational uses. The scope of likely industrial development has been described in Chapters IV and V.

NATIVE ALLOTMENTS

According to the full development scenario (fig. V-1), four Native Allotment parcels occur in areas of petroleum potential in Block C. Six Native parcels comprising 240 acres could be in the area that may be developed as a port facility at Camden Bay and two parcels totaling 120 acres are in the area at Pokok, also a potential port site.

Because of the relatively small size, scattered location, and general lack of overlap with potential prospects, allotments generally would not conflict with their development.

Subsurface ownership under an allotment is reserved to the government. The allotment owner is subject to the right of the government or its lessee to enter and use the lands for the development of the reserved minerals, subject to the duty to pay for damages to surface improvements and a bond to guarantee such payments.

STATE AND LOCAL POLITICAL AND ECONOMIC SYSTEMS

Full leasing of the 1002 area would produce State and local economic benefits. Effects on national economics are discussed in Chapter VII. Income from the State's share of revenues derived from Federal oil leases on the coastal plain and from corporate taxes levied on the oil industry could produce major economic benefits to the State of Alaska. The State would also receive additional revenues through corporate taxes from any oil development on Native-owned areas adjacent to the 1002 area. Some minor secondary economic effects could result from employment and population increases in Anchorage, Fairbanks, and south-central Alaska. These effects would be similar to those described in the Beaufort offshore sale evaluations (U.S. Minerals Management Service, 1984), which estimated a 3-percent increase.

~ As is common at Prudhoe Bay, almost all the permanent jobs would be expected to be filled by commuters who would be present at worksites approximately half the time each year (job sharing on a 24-hour basis) but who would not reside on the North Slope. The number of jobs filled by permanent residents of the North Slope, most of whom are Inupiat, would be expected to be small, based upon experience at the Endicott and Prudhoe Bay oil developments. According to the U.S. Minerals Management Service (1984), a survey of workers at Prudhoe Bay showed that of 6,306 workers, only 178 (fewer than 3 percent) claimed either no permanent residency or a North Slope residency. According to information provided by ARCO, most of their Prudhoe Bay employees reside in the greater Anchorage area. ~

There will be an overall beneficial economic effect on the North Slope Borough through substantial increases in tax collections and other revenue generated from development and production on the 1002 area. The Borough would increase its tax base to the extent Native-owned lands were placed in commercial development status. ASRC would obtain substantial revenues through lease, exploration, and production of oil from its lands.

Local economic benefits to Kaktovik would result from establishment of some support industries there, purchase of goods and services by oil-field workers who visit Kaktovik, and income from those local residents who obtain employment in the oil fields.

Conclusion

Major positive State and local economic effects would be expected from subsequent revenue from leases and taxes, increased local population and employment base, and other aspects of oil development.

PUBLIC SERVICES AND FACILITIES

Transportation facilities associated with full leasing could result in increased and better connections between Kaktovik and Prudhoe Bay, as well as with TAPS and the rest of Alaska. The existing Dalton Highway, adjacent to TAPS and connecting Prudhoe Bay with Fairbanks and other highways in Alaska, has sufficient capability to handle increased traffic during exploration, construction, operation, and rehabilitation with only negligible effect. Similarly, the capacity to handle increased movement of goods and supplies through Valdez, Whittier, Anchorage, and Fairbanks would only negligibly affect the existing transportation infrastructure.

The long-term capital improvement program of the North Slope Borough would be beneficially affected insofar as oil-field facilities in the 1002 area increased the Borough's tax base. This positive effect on the Borough's economy would increase its ability to provide improved public services.

Conclusion

Restricting uses of the transportation infrastructure to those directly associated with oil development, as required to minimize effects on fish and wildlife species, will limit increased transportation opportunities which would otherwise result from full leasing. Additional borough and local revenues will likely result in overall major increases in available public services.

ARCHEOLOGY

More than 100 archeological sites have been identified on the 1002 area. Thirty-four of these sites are recognizable structures such as cabins, caches, or graves, all but two of them on the coastline. The other sites, mainly tent rings, are situated along the primary rivers 2 to 33 miles upstream from the coast.

Conflict between known archeological sites and projected oil-field development might occur at Camden Bay and Pokok due to construction of marine and waterflood facilities at these locations (pl. 1A). Four known sites occur at Camden Bay and three at Pokok.

Mitigation

Because known archeological sites are small and precisely located, they can be easily avoided during construction and operation of nearby facilities. Before exploration or development work, contractors would be required to conduct archeological surveys in all areas that may be affected. Most, if not all, sites discovered in this process could be protected by avoidance. The preponderance of known sites and most likely the majority of undiscovered sites occur along the coast and major rivers, in areas that will be avoided for other reasons. Nonetheless, contractors will be required to exercise caution in their operations, and to cease activity when an archeological site is encountered until appropriate protective measures are adopted.

Conclusion

Impacts on archeological resources of the 1002 area should be negligible. A minor positive benefit may occur through the discovery, evaluation, and protection of additional archeological sites during oil exploration and development.

RECREATION, WILDERNESS, AND ESTHETICS

Most recreationists currently visit the 1002 area for a wilderness experience and would likely perceive the existence of oil facilities in the area as lessening the quality of that experience. Fewer than 150 recreationists of all types (exclusive of local residents from Kaktovik) currently visit the 1002 area annually. Several hundred visitors fly over the area to sightsee or enroute to other destinations on the refuge.

Effects on recreation would result from activities affecting esthetics and access. The visual aspect of the 1002 area as a broad trackless wilderness would be destroyed by the addition of oil facilities. Those individuals desiring to fly over, photograph, or otherwise partake of a pristine Arctic wilderness experience may consider this a major adverse effect. Similarly, those floating down rivers such as the Canning, Hulahula, and Aichilik may be esthetically disturbed by the sight of bridges, pipelines, or other facility crossings. For recreationists other than those seeking a wilderness experience, increased ease of entry would be considered an improvement. The addition of roads, pipelines, airfields, and other infrastructure within the 1002 area will undoubtedly improve access. Of course, use of that access will generally be restricted so as to minimize negative effects of development on fish and wildlife resources. Access also may be limited for safety and security reasons. Notwithstanding that limitation, experience on the Dalton Highway has shown that unauthorized public use is difficult to curtail.

Oil development and the associated infrastructure may displace some hunted and trapped species, adversely affecting recreational hunting and trapping opportunities. Because much of that displacement would be from the area in which discharge of firearms would be prohibited and access would be restricted, the net effect on hunters would be negligible.

Because of the negative stimulus conditioning on some species, such as caribou, the quality of wildlife observation, a popular recreational activity on the refuge, would be reduced.

Noise and presence of oil-development facilities would not only eliminate the wilderness character in the 1002 area, but there could also be some visual and sound intrusions in the designated Wilderness by activities and developments in the adjacent 1002 area. The existence of oil facilities and activities would eliminate the opportunity for further scientific study of an undisturbed ecosystem.

Mitigation

With careful planning and coordination for other reasons, each river should generally have only one crossing facility throughout its length. Negative effects on recreationists in the adjacent wilderness could be mitigated somewhat if, wherever possible, no facilities were placed within 5 miles of designated wilderness. Loss of the area's wilderness character cannot be mitigated where oil exploration and development occur.

Conclusion

The expected displacement and reduction of wildlife populations and natural processes would cause a major reduction in the value of the area as a pristine, natural scientific laboratory. The wilderness value of the coastal

plain of the Arctic Refuge would be eliminated, except for the area of the refuge east of the 1002 boundary between the Aichilik River and the Canadian border which is designated wilderness.

Summary of Unavoidable Impacts, Alternative A

Translocation of gravel from natural sites to oil activity areas resulting in local changes in topography.

Use of limited natural fresh-water sources for industrial uses.

Some thermokarsting, erosion, and melting of permafrost.

Compaction, destruction and delayed growth of vegetation in areas of further geophysical exploration (green and brown trails).

Direct loss of approximately 5,650 acres of coastal plain habitat to road and pad construction and gravel borrow sites.

Modification of about 7,000 additional acres of coastal plain habitat due to secondary effects of gravel spray, dust deposition, and altered snowmelt and erosion patterns.

Increased noise and other disturbance factors.

An unknown number (possibly hundreds) of minor spills (diesel fuel, oil, antifreeze, etc.) resulting from vehicle and equipment operation, causing some destruction of vegetation, contamination of waters, and mortality of small food organisms.

~ Reduced use by caribou of up to 37 percent (303,000 acres) of concentrated calving areas. ~

Possible reduced use through avoidance of approximately 72,000 acres of insect-relief habitat for caribou.

Direct loss of approximately 2,700 acres of muskoxen habitat due to placement of facilities and pipelines.

Disturbance and possible avoidance by muskoxen of 71 percent of their high-use, year-round habitats, resulting in a change in distribution, population decline, or limitation on expansion of the 1002 area population.

Direct loss of approximately 140 acres of moose habitat.

Moderate decline in the wolf population due to cumulative increase in mortality and decrease in production or survival resulting from reduced prey availability.

Displacement and increased harvest of wolverines.

Direct loss of 3,500 acres of brown bear high- and moderate-use habitats.

Probable loss of approximately one brown bear per year from accidents or from being shot in defense of life or property.

Direct and indirect small mammal loss due to habitat destruction, road kills, etc.

~ Probable loss of the eastern part of the 1002 area as denning habitat for polar bears, if a marine/port facility is located there. ~

Direct loss of 2,000 acres of snow goose preferred staging habitat.

Decreased habitat values on 162,000 to 236,000 acres of snow goose preferred staging habitat.

Direct mortality of an unquantifiable number of birds due to collisions with towers, antennas, wires, and other structures.

~ Minor decline or change in distribution of golden eagles as a result of decreased caribou prey. ~

Moderate loss of arctic grayling habitat in Block A due to stream alterations.

~ Accelerated rate of change in traditional Native culture and probably some cultural disorientation. ~

~ Loss of subsistence hunting opportunities throughout approximately one-half the 1002 area and possible reduction in subsistence opportunities to communities outside the 1002 area that are dependent on harvest of migratory fish and wildlife populations that spend part of their time on the 1002 area. ~

Unquantifiable loss of wilderness values throughout the entire 1002 area.

ALTERNATIVE B--LIMITED LEASING

~ Under limited leasing the area designated as the repeatedly used concentrated calving area for the PCH would not be leased. This would include all or part of Block D. The analysis for this alternative is based on the same methods and assumptions used for Alternative A and described in the introduction to this chapter. As depicted in figure V-2, the development scenario has no surface occupancy in the southeastern part of the 1002 area (that is, no access road extending south from the main east-west road nor other support infrastructure, drill pads, exploration, or production facilities). ~

Both the effects and mitigation measures described by species under the full leasing alternative apply within the scope of development likely for leasing a portion of the 1002 area. In this discussion these references and

discussions will be summarized. If there is a change in level or type of effect anticipated between full development and limited development, it will be emphasized at the end of the appropriate discussion.

Effects on Physical Geography and Processes

Effects on the physical environment resulting from a limited leasing program would be similar to those resulting from full leasing, but to a lesser degree. Most important is the fact that by not developing economic prospects in all or part of Block D, water and gravel requirements could be reduced by up to one-third. Some of this reduction would occur outside Block D if water and gravel sources that would support development in that area were located elsewhere. Additionally, expected increases in noise levels would not occur in the portion of the 1002 area which is not leased.

~ As noted in the discussion on the full leasing option, current EPA and Alaska regulations are sufficient to ensure that there will be no significant deterioration of air quality. ~

Effects on Biological Environment

VEGETATION, WETLANDS, AND TERRAIN TYPES

The exploration associated with limited leasing would require additional seismic surveys and exploration wells. As described for full leasing, these activities would result in visible trails, toxic material spills, soil compaction, and delayed plant growth under ice roads, airstrips, and drill pads. With the restriction on surface occupancy of the southeastern portion of the 1002 area, approximately one-fifth less area than under full leasing would be subject to these effects.

Approximately 3,800 acres, compared to 5,000 acres under Alternative A, would be covered with gravel for roads, drill pads, airstrips and other facilities. This decrease in gravel needs would result in 400-650 acres of gravel sites, a reduction of 100 acres from Alternative A.

Secondary habitat modifications resulting from gravel spray, dust, and changes in snow accumulation patterns would affect nearly 5,200 acres, 1,800 acres less than under full leasing. The possibility of habitat destruction or degradation from toxic materials and sea-water spills would be eliminated in the repeatedly used concentrated PCH calving habitat, and reduced in snow goose staging habitats.

The candidate plant *Thlaspi arcticum* is not known to occur in the area deleted from leasing under this alternative. Consequently, effects would be the same as for full leasing: potential loss of plants and habitat from gravel placement, dust deposition, or other development activities.

Mitigation

As for Alternative A, consolidation of facilities, environmentally sensitive engineering, and control of toxic materials as described under full leasing could help reduce the area and magnitude of effects to vegetation and wetlands.

Conclusion

The expected total modification of existing vegetation and wetlands, both primary and secondary, because of gravel placement and associated secondary modifications for drill pads, roads, and other oil development facilities, would be nearly 9,600 acres (over 0.6 percent of the 1002 area) or 3,000 acres less than the area to be modified by full development. The effect would remain minor.

~ SPECIAL TERRESTRIAL AND AQUATIC ENVIRONMENTS ~

The prohibition on activities in the Sadlerochit Spring area would prevent most negative effects. With no development in the southeastern portion of the 1002 area, oil development and personnel would be located much farther from the Sadlerochit Spring Special Area. Consequently, the likelihood of increased visitor use would be greatly reduced, preventing disturbance, any noticeable increase in fishing pressure, or competition with local Native subsistence use in that area. Impacts to the two other potential National Natural Landmarks (Kongakut River-Beaufort Lagoon and Angun Plains) and the proposed Jago River Ecological Reserve/Research Natural Area are expected to be the same as in Alternative A.

Mitigation

Limiting surface occupancy in the zone from the coastline inland 3 miles would effectively mitigate impacts in the Kongakut River-Beaufort Lagoon area. Gravel extraction should be limited in the Angun Plains. Any proposal for gravel extraction within this potential National Natural Landmark should be evaluated for possible adverse impacts to the geologic features which make this area unique. The need for Research Natural Areas on the North Slope should be reviewed and specific locations (if any) within the Jago River drainage that meet these needs should be identified.

Conclusion

Under current protective management stipulations and proposed mitigation, effects would be negligible to the Sadlerochit Spring Special Area, proposed Kongakut River-Beaufort Lagoon National Natural Landmark, and the proposed Angun Plains National Natural Landmark.

No attempt has been made to assess the level of effects on the proposed Jago River Ecological Reserve/Research Natural Area because specific areas for inclusion in this reserve have not been identified.

COASTAL AND MARINE ENVIRONMENT

Limited leasing would affect coastal and marine environments at nearly the same level as full leasing. Although support requirements may decrease because of reduced inland development and use of coastal areas, two port sites are still recommended to support the limited development program, just as they were for full leasing, because of development in Block C. Spills of oil or other hazardous materials along the coast could severely affect coastal and marine habitats and fish and wildlife.

Mitigation

Environmentally sensitive construction of docks and causeways as well as proper management of fuel and other hazardous substances will minimize most adverse effects.

Conclusion

Because coastal activities would only be slightly less in magnitude but not area, a minor effect would result from limited leasing. Again, the cumulative effects of future developments or an oil spill could be major.

TERRESTRIAL MAMMALS

~ CARIBOU ~

With limited leasing, direct modification of caribou habitat would be 4,400 acres. Secondary habitat changes due to dust and gravel spray would be 5,200 acres. This could result in total habitat modification of approximately 9,600 acres. Reduction in habitat modification and decreased human activities would be within areas used by the PCH. Effects on the CAH, which occupies the western portion of the 1002 area, would be the same as for full development.

Much of the PCH's repeatedly used concentrated calving areas, as determined from historical information, would not be leased (pl. 2A). The final determination of the excluded area would be based on the area that represented repeated use in approximately half of the years for which data were available.

In addition to reductions of direct habitat loss, the absence of human disturbance would significantly reduce behavioral avoidance of and obstacles to free movements among insect-relief, foraging, and predator-avoidance habitats, particularly by maternal cows and calves. The 3-km sphere of influence (Dau and Cameron, 1986) used to assess effects as described in Alternative A would mean reduced habitat use on up to approximately 214,000 acres

(26 percent) of the PCH's concentrated calving area within the 1002 area (table VI-4). This would affect 89,000 acres less than the area of reduced use projected under full development. Some 96,000 of those acres (12 percent) would be within the 0- to 1-km zone and 72,000 acres (9 percent) would be within the 1- to 2-km zone.

Not leasing the southeastern portion of the 1002 area would eliminate obstacles to free movement of caribou in Block D. This would allow caribou free access to the calving areas of greatest sustained use (Elison and others, 1986), as well as to some areas used for foraging and predator avoidance. Access to coastal insect-relief areas could still be inhibited as the east-west transportation/pipeline corridor would not be changed, although traffic levels may be somewhat reduced. The 3-km sphere of influence suggested for assessing effects relative to caribou use of insect-relief habitats would mean reduced use of up to 68,000 acres of insect-relief habitat. Over 80 percent of coastal insect-relief habitats could remain unavailable under limited leasing if caribou do not cross the main pipeline/road system.

Effects of disturbance from aircraft and other activities would be similar to but somewhat less intense than those described for Alternative A.

Mitigation

All measures recommended for Alternative A (for example, pipeline design, limiting use of the infrastructure to development, environmentally sensitive siting of all facilities, time and area closures, access restrictions) would apply in avoiding, minimizing, or otherwise mitigating potential adverse effects to caribou.

Conclusion

Only negligible effects on the PCH and minor effects on the CAH would be expected from further exploration with well drilling and seismic activities confined to the winter season.

The same amount of disturbance, barriers to free movement, and other adverse effects of oil development could affect the CAH as under Alternative A, because the level of activity would be the same in the portion of the 1002 area they use. Effects on CAH caribou by petroleum development would remain minor under the limited development probable in Alternative B.

Effects on the PCH could be moderate as a result of oil-related activities occurring in all but their repeatedly used concentrated calving area (Block D). Disruption of calving activity and foraging could still occur within other parts of the 1002 area used by the PCH. As with Alternative A, some change in distribution and population could be expected to occur; it can be assumed to be less than changes resulting from disturbance in highly preferred calving habitat. Nonetheless, predicting a population

decline is not possible, but no appreciable decline would be expected.

Obstacles to accessing insect-relief habitats would not be significantly different in this alternative. As discussed in Alternative A, failure to obtain insect-relief could lead to poor physical condition, increased susceptibility to predation if insect-relief areas south of the 1002 area are sought out as an alternative, and reduced overwinter survival. This could disproportionately affect cows with calves, which could be expected to reduce recruitment.

MUSKOXEN

Limited leasing would reduce the effects of oil development on the small subpopulation of muskoxen in the Niguanak-Okerokovik-Angun River area (pl. 2C). Effects upon muskoxen elsewhere on the 1002 area would remain the same as those for full development. Direct habitat modification would be approximately 2,400 acres (0.3 percent of muskox habitats). Assuming muskoxen are displaced 2 miles away from all development facilities (Russell, 1977; Reynolds and LaPlant, 1985), then habitat value losses would occur on 254,000 acres of muskox habitat (table VI-6). This loss in habitat values represents approximately one-third of the muskoxen range. Habitats used for high seasonal or year-round use, including calving, would be disproportionately affected; muskoxen could be displaced from approximately 52 percent of those habitats-- a 1 percent decrease from the loss expected under full development. Mortality from hunting, collisions with vehicles, and other accidents would be little changed because development would occur throughout most of the same muskoxen habitats.

Mitigation

Because essentially the same muskoxen habitats would be affected by limited development, mitigation recommendations would be identical to those for full development.

Conclusion

~ Effects of limited development could be major. Although a major population decline is unlikely, the muskox herd is not likely to continue increasing in numbers or expanding its range at the current rate. Muskoxen and their habitats would be adversely affected to essentially the same degree by either full or limited development. ~

MOOSE

Effects of limited leasing upon the moose population would be substantially reduced, because most moose habitat affected under full leasing is in Block D, which would not be leased. Direct habitat loss would be reduced to 10 acres from 140. The reduced numbers and proximity of the workforce to moose would lessen the potential for direct mortality, the primary adverse effect.

Mitigation

No mitigation is necessary beyond those measures recommended under full leasing.

Conclusion

Under limited leasing, the overall effect on the moose population would be reduced from minor to negligible, with elimination of nearly all habitat loss and vehicle movement in moose habitats.

DALL SHEEP

Few effects on Dall sheep are anticipated under limited leasing. Aircraft harassment and hunting pressure in areas adjacent to the 1002 area might be slightly reduced if fewer personnel are in the area, particularly in those areas closest to Dall sheep habitats.

Mitigation

As for full leasing, more restrictive hunting regulations could be required.

Conclusion

Effects on Dall sheep would be negligible.

WOLVES

Direct habitat loss would be negligible. Protection of a portion of the PCH concentrated calving area would help ensure the availability of an important prey species for wolves. Intrusion of development into some wolf habitat and direct mortality would be reduced from that expected from full development.

Mitigation

Measures for adequate garbage control and enforcement of hunting regulations would be required as for full development.

Conclusion

The effect on the wolf population would be minor.

ARCTIC FOXES

Direct mortality, habitat loss, and artificial feeding would occur in all but the undeveloped areas in Block D.

Mitigation

No additional mitigation beyond that recommended for other species would be needed to reduce or eliminate effects on fox.

Conclusion

Effects on arctic fox would be minor.

WOLVERINES

Limited development would result in localized, long-term displacement of a few wolverines in all but the southeastern part of the 1002 area. Reduction of wolverine displacement and of adverse effects on prey species and their predators would result in somewhat less severe effects on wolverines under the limited as compared with the full leasing alternative. Increased human activities could lead to increased harvest.

Mitigation

Minimizing adverse effects on prey species and controlling access and harvest will help minimize the effect on wolverines.

Conclusion

Although the area affected is reduced from full leasing, the cumulative effects of displacement or avoidance, reduced food resources, and increased harvest would still result in localized, long-term changes in wolverine distribution, affecting a few individuals. Because wolverines are sensitive to disturbance and human predation, the effects on them could be moderate.

BROWN BEARS

Development of potentially economic prospects within Blocks A, B, and most of C would affect areas used seasonally by brown bears at moderate to high density (pl. 1D). Direct habitat loss would be approximately 2,600 acres. Oil-field development would take place in 11 percent of brown bear high- and moderate-use areas (compared to 17 percent under full development). The limited leasing alternative would reduce adverse effects by protecting a portion of the concentrated calving area of the PCH, an important prey species for brown bears. Encounters between humans and bears may also be somewhat reduced, but some direct mortality of nuisance bears would be expected to occur throughout the remainder of the 1002 area.

Mitigation

Controls on handling garbage, on harvest, and aircraft overflights; fencing; monitoring; and one-half mile buffer zones of no activity around dens (described under Alternative A) would mitigate adverse effects.

Conclusion

The overall population reduction or change in distribution of brown bears as a result of direct mortality,

harassment, loss of feeding habitat, and disturbance in denning areas would be reduced from moderate to minor, because their use of the Block D area concentrated calving area as an important feeding site would not be disrupted.

ARCTIC GROUND SQUIRRELS AND OTHER RODENTS

Localized habitat alterations and road kills would result from this alternative. Potential positive effects of protective cover in and under structures and debris could similarly result.

Mitigation

No additional mitigation is recommended.

Conclusion

Effects on these species would be minor due to local habitat losses and road kills.

MARINE MAMMALS

POLAR BEARS

Areas deleted under limited leasing have generally not been used by denning polar bears. The reduced overall activity (less vehicle, sealift, and air-support traffic) would not appreciably reduce potential disturbance of polar bears, because the more highly used areas around the coast and in Block C would be open to potential development.

Mitigation

No additional mitigation measures are recommended beyond those for Alternative A. Development of a marine facility at Pokok and its subsequent use would result in the loss of repeatedly used denning habitat.

Conclusion

The overall effect of limited leasing would be moderate, mainly arising from the adverse effects associated with proposed marine facilities, particularly those at Pokok.

SEALS AND WHALES

Activity, noise, altered habitats, and changes in availability of food sources from dredging and causeway construction and operation, ships and barges, and aircraft could adversely affect seals and whales. The effects may be somewhat less than for full leasing because the reduced number of oil facilities could reduce the level of coastal logistical activities.

Mitigation

Recommended measures for full development would also apply to limited development. If marine facilities in the

Pokok area were not developed, the adverse effects of disturbance, noise, lost food resources, and altered habitats would be further reduced.

Conclusion

Effects on seal and whales would be minor.

BIRDS

SWANS, GEESE, AND DUCKS

Direct and indirect habitat loss would be reduced somewhat as a result of limiting the development area. However, with the exception of snow geese, the area eliminated from leasing is not heavily used by waterfowl.

For snow geese, the direct loss of use areas would be 1,970 acres. A loss of 1,200 acres of preferred habitat is expected, nearly 800 acres less than expected from full development. The primary adverse effect, indirect habitat loss due to displacement, would also be substantially reduced.

Potential displacement would be reduced to between 95,000 and 135,000 acres, or as much as 26 percent (as compared with 45 percent under full development) of preferred snow goose staging habitats, resulting in moderate effects on population distribution and numbers (table VI-7).

Mitigation

Mitigation of impacts on swans, geese, and ducks would be the same as for Alternative A.

Conclusion

For waterfowl species other than snow geese, the cumulative effects of disturbance, habitat alteration, direct mortality, and contaminants would be minor. Disturbance could cause a moderate reduction in population or change in distribution for as much as 26 percent of the snow geese using the 1002 area (5 percent of the Western Arctic snow goose population).

SEABIRDS AND SHOREBIRDS

Under limited development, activities in coastal areas would be little reduced from those under full development. Consequently, effects on seabirds and shorebirds would be little changed. The potential for contaminant spills in developed areas would remain. Although the areas which would be deleted from leasing are not sites of high seabird and shorebird density, several species, such as jaegers and plovers, nest and feed there. These birds would be unaffected by construction, traffic, noise, gravel placement, and other disturbances associated with development in other parts of the 1002 area.

Mitigation

Recommended measures would be the same as for Alternative A.

Conclusion

Overall population changes and habitat loss would be minor. Moderate effects may result from development in areas of high use by seabirds and shorebirds. Bird mortality and reduced food resources could occur in the event of spills of oil or other contaminants.

RAPTORS

~ Development could conflict with raptor nesting habitat in Block A but would not with nesting habitats in the southeastern portion of the 1002 area. The reduction in golden eagle prey expected from adverse effects on the PCH concentrated calving area caused by development would not occur with reduction or elimination of activities in Block D. ~

Mitigation

Mitigation measures designed for full development would apply, including activity restrictions near nest sites.

~ Conclusion ~

Because of a relatively protected prey base, changes in population and distribution of golden eagles would be decreased, although they would remain minor. Effects on other raptors would also be minor, and the potential for conflicts with nesting habitat would be somewhat reduced.

PTARMIGAN

Not leasing the southern part of the 1002 area would reduce potential losses of some ptarmigan habitat.

Mitigation

Recommendations under full leasing would apply.

Conclusion

The effect of limited oil development on ptarmigan would be negligible.

PASSERINES

Adverse effects (habitat loss and disturbance, contaminants, and possibly decreased nesting opportunities or food availability for some species) would occur for passerine bird species except those using habitats in Block D. Those effects are described in Alternative A.

Mitigation

Measures would be as recommended under full leasing.

Conclusion

Effects on passerines would be minor.

FISH

Effects on fish under limited leasing would be similar to those under full leasing, although access corridors along the Hulahula River to development in the southeastern part of the 1002 area would no longer be required. Consequently, effects on arctic char and arctic grayling using the Hulahula River system would be eliminated, with the exception of some fishing pressure and one crossing by the main east-west pipeline-road corridor. Reduced gravel and water needs, fewer stream crossings, elimination of some potential for oil spills, and reduced human access and fishing pressure would reduce effects on arctic grayling in the Okpilak River drainage.

Mitigation

The same measures as those recommended for Alternative A would be appropriate for this alternative.

Conclusion

Effects on fish should be minor. An oil spill in a waterway or along the coast could have a major effect on fish populations.

THREATENED AND ENDANGERED SPECIES

BOWHEAD AND GRAY WHALES

See discussion under Seals and Whales.

ARCTIC PEREGRINE FALCON

Disturbance and reductions or displacement of prey would adversely affect peregrine falcons. The potential for conflicts between development and historic peregrine nest sites would be eliminated, because there would be no development, and probably no water withdrawal, near either known nest sites or much of the cliff-nesting habitat.

Mitigation

Measures would be the same as those recommended for Alternative A.

Conclusion

Effects of development, disturbance, and reduced prey throughout the 1002 area except in Block D would have negligible impacts on peregrines.

Effects on Human Environment

POPULATION

Development would require approximately one-third fewer workers and support personnel under limited leasing than under full leasing. Employment opportunities during construction and restoration phases would total approximately 4,000 jobs. Permanent employment during production would range from 400 to 1,000 jobs during the 30-year lifetime of the oil fields.

The year-round population at Kaktovik would increase somewhat, but less than for full leasing. Most workers would still be expected to maintain permanent residences elsewhere, similar to workers at Prudhoe Bay.

Conclusion

The expected population increase would be minor in Kaktovik and negligible to minor in other Alaska communities.

~ SOCIOCULTURAL SYSTEM ~

The sociocultural changes discussed in Alternative A would exist under this alternative, although possibly to a lesser extent. Subsistence harvest would not be as adversely affected; one-third fewer workers will be in the area and the economic stimulus to the area will be somewhat less. All the impacts mentioned in Alternative A are likely in this alternative, but to a lesser degree. ~

Mitigation

All the mitigation measures mentioned in Alternative A should be considered for this alternative.

Conclusion

Major sociocultural changes could be anticipated, as described in Alternative A.

EXISTING LAND USE

~ SUBSISTENCE USE ~

Under Alternative B, villagers from Kaktovik could continue to pursue subsistence hunting of caribou in the southeastern part of the 1002 area. Competition with oil-field workers for harvest of fish and wildlife resources would still occur. Intrusion of development activities into traditional harvest areas could occur in all but the southeastern part of the 1002 area.

With much of the PCH's repeatedly used concentrated calving area protected from leasing, impacts to subsistence harvest of PCH caribou by residents of Kaktovik, Arctic Village, and Old Crow, as well as other Alaska and Western Canada communities whose residents use this herd, would be reduced, if not largely eliminated.

Mitigation

As for full leasing, mitigation applicable to species used for subsistence would also lessen effects on subsistence harvest. However, policies designed to reduce disturbance and other adverse effects on fish and wildlife species by restricting access and harvest in some areas would adversely affect subsistence use, mainly for residents for Kaktovik.

Conclusion

Unlike Alternative A, limited leasing under Alternative B should significantly reduce impacts to subsistence uses outside the 1002 area--such as in the communities of Arctic Village and Old Crow, and other Alaska and Western Canada communities dependent on both migratory PCH caribou and waterfowl.

However, petroleum development in the 1002 area, except in the repeatedly used concentrated calving area of the PCH, would still have adverse effects on the subsistence activities of the residents of Kaktovik. For them, a significant restriction of subsistence hunting would be expected to result. ~

If the Congress enacts legislation to authorize the Department of the Interior to lease a portion of the 1002 area, then the Secretary of the Interior must, prior to actual lease sales, determine the effects on subsistence of such an action in compliance with section 810 of ANILCA.

LAND STATUS AND MILITARY AND INDUSTRIAL USE

Land ownership would not change under this alternative, nor would any change in existing military activities be expected. Industrial development would occur in an area currently devoted to Native subsistence, fish and wildlife management, and recreational uses.

NATIVE ALLOTMENTS

None of the 1002 area parcels for which Native allotment applications have been made are in the area deleted from leasing; therefore, the areas affected would be the same as for Alternative A.

STATE AND LOCAL POLITICAL AND ECONOMIC SYSTEMS

Economic benefits at the Federal, State, and local levels would still occur as described under Alternative A

and in Chapter VII. These benefits could be one-third less than those for full leasing and development because the development of revenue-producing oil resources may possibly be that much less.

Conclusion

Although the overall benefits might be smaller than those expected to result from full leasing and development, limited leasing would be a major positive benefit to State and local political and economic systems.

PUBLIC SERVICES AND FACILITIES

The tax base and employment opportunities would be approximately one-third less than for Alternative A.

Conclusion

The overall effect of increased public services and facilities would be a major benefit.

ARCHEOLOGY

Potential conflict between known archeological sites and projected oil-field development might occur in four instances at Camden Bay and three at Pokok as a result of construction of marine facilities. Development would take place at nearly the same level in coastal and river areas where undiscovered archeological sites are most likely to occur.

Mitigation

Surveys in areas to be developed and avoidance of known or discovered archeological sites will minimize the potential for site destruction.

Conclusion

Effects would be negligible.

RECREATION, WILDERNESS, AND ESTHETICS

The wilderness character would be destroyed except in the southeastern part of the 1002 area and immediately adjacent wilderness areas.

Mitigation

Limiting numbers of river and stream crossings and not siting development facilities within 5 miles of designated wilderness areas would reduce adverse visual effects within the 1002 area and in adjacent designated wilderness areas.

Conclusion

A major loss of the wilderness character would occur.

Summary of Unavoidable Impacts, Alternative B

Translocation of gravel from natural sites to oil activity areas, resulting in local changes in topography.

Use of limited natural fresh-water sources for industrial purposes.

Some thermokarsting, erosion, and melting of permafrost.

Compaction and destruction or delayed growth of vegetation in areas of further geophysical exploration (green and brown trails).

Loss of nearly 4,400 acres of habitat to road and pad construction and gravel borrow sites.

Modification of about 5,200 additional acres of habitat due to secondary effects such as gravel spray, dust deposition, and altered snowmelt and erosion patterns.

Increased noise and other disturbances displacing wildlife throughout all but the southeastern part of the 1002 area.

An unknown number of small spills (diesel fuel, oil, antifreeze, and so forth) resulting from vehicle and equipment operation and causing destruction of vegetation, contamination of waters, or mortality of small food organisms.

~ Reduced use of caribou from 26 percent (214,000 acres) of the concentrated calving areas, causing some distribution change for the PCH. ~

Reduced use or avoidance of approximately 68,000 acres of insect-relief habitat for caribou.

Direct loss of approximately 2,400 acres of muskox habitat.

Increased disturbance and possible avoidance by muskoxen of 70 percent of calving and other high-use, year-round habitats, resulting in a change in distribution, population decline, or no further expansion of the 1002 area muskox population.

Direct loss of approximately 10 acres of moose habitat.

Minor decline in the wolf population mainly due to increased mortality.

Displacement and increased harvest of wolverines.

Direct habitat loss of 2,600 acres of brown bear high- and moderate-use areas.

Possible loss of approximately one brown bear per year from accidents or from being shot in defense of life or property.

Direct and indirect small mammal loss due to habitat destruction, road kills, and so on.

Probable loss of the eastern portion of the 1002 area as denning habitat for polar bears.

Direct loss of 1,200 acres of snow goose preferred staging habitat.

Reduced use of 95,000-135,000 acres of snow goose preferred staging habitat.

Direct mortality of an unquantifiable number of birds due to collisions with towers, antennas, wires, and other structures.

Moderate loss of arctic grayling habitat in Block A owing to stream alterations and direct mortality.

~ Accelerated rate of change in traditional Native culture and probably some cultural disorientation. ~

~ Loss of subsistence hunting opportunities in 40-50 percent of the 1002 area and possible reduction in subsistence opportunities to those communities outside the 1002 area that are dependent on harvest of migratory fish and wildlife populations that spend part of their time on the 1002 area. ~

Unquantifiable loss of wilderness values in approximately 80 percent of the 1002 area.

ALTERNATIVE C--FURTHER EXPLORATION

The first activities associated with further exploration would be additional seismic work and surface geology studies. The effects of these exploration activities are fully described under Alternative A. Alternative C provides an opportunity to collect further information regarding possible impacts of oil development, because exploration wells not previously permitted on the 1002 area would be allowed. This would assist in more accurately predicting environmental impacts and planning mitigation, should leasing be considered at some future date.

Effects and mitigation previously described for Alternatives A and B are referenced. Previously discussed literature on effects of exploration activities is also applicable.

Effects on Physical Geography and Processes

The physical effects to be expected from additional surface geology and seismic exploration as well as from the drilling of several stratigraphic test wells would be identical to those described in the seismic exploration and exploratory drilling discussions under Alternative A.

Effects on Biological Environment

VEGETATION, WETLANDS, AND TERRAIN TYPES

Effects would be similar to those described for exploration under Alternative A. The generally temporary nature of exploration activities and the possible location of test wells (Chapter V) would result in a negligible effect on the vegetation, wetlands, and terrain types of the 1002 area.

~ SPECIAL TERRESTRIAL AND AQUATIC ENVIRONMENTS ~

Given current management regulations, no impacts would occur within the Sadlerochit Spring Special Area. Impacts on the other two proposed National Natural Landmarks would be negligible. Effects on the proposed Jago River Ecological Reserve/Research Natural Area are not assessed inasmuch as specific areas for inclusion in this reserve have not been identified.

COASTAL AND MARINE ENVIRONMENT

Effects would be negligible because exploration activities causing debris and disturbance would be minimal and of a temporary nature. No greater than local, small contaminant spills are likely.

FISH AND WILDLIFE RESOURCES

Further exploration, including the construction and drilling of single-season or winter only multi-season exploratory wells, would result in only minor or negligible effects on the fish and wildlife resources, as assessed in Alternative A. Fish and wildlife species which would be most affected by exploration activities are generally absent from the 1002 area during the winter when these operations would take place. Further exploration involves short-term, local activities which would disturb or displace only wildlife in the immediate vicinity. Although surface geology work would take place during the summer when fish and wildlife use is greatest, such work is very short-term, extremely localized, and results in almost no noticeable impacts.

The only species on which minor rather than negligible effects might occur are those few CAH caribou that use the 1002 area during the winter, muskoxen, and polar bears. Short-term, localized displacements of CAH caribou and muskoxen could occur near exploration activities. Polar bears could be disrupted from denning, as was suspected to be the case for one bear during the 1984-85 seismic program on the 1002 area.

Mitigation measures applicable to further exploration would be those in the regulations and special use permits governing the previous exploration programs in the 1002 area and the stipulations in the Chandler Lake Agreement for the exploratory well on the KIC/ASRC lands. Additional measures applicable to exploration are detailed under

Alternative A (time and area closures; aircraft altitude restrictions; control of access, harvest, and contaminants; and actively monitoring all exploration activities as well as wildlife activities).

~ Effects on Human Environment ~

A moderate effect on wilderness could be expected from further exploration. Seismic trails and well pads are visual remnants of exploration which may persist for several years, reducing the wilderness value of areas in which they occur. Rehabilitation of well pads would be slow, and the effects on the wilderness values of the area in and around pads would be moderate. Adequate snow cover to protect the surface, environmentally sensitive routing of trails, and other mitigation stipulations described for Alternative A and used in the previous 1002 area and KIC/ASRC exploration programs would minimize effects on recreation and subsistence use, and archeology.

Reduction and displacement of fish and wildlife populations used for subsistence would be no more than minor; access to traditional harvest areas would generally not be inhibited; and potential psychological effects would be greatly reduced as a result of the local, temporary activities involved in further exploration. As described under Alternative A, previous evaluations of the effect on subsistence from 1983-85 surface geology and seismic exploration programs have concluded that effects on subsistence use would be minimal and there would be no significant restriction of subsistence use (U.S. Fish and Wildlife Service, 1983a, b; 1984a, b; 1985). Other sociocultural systems of the area would not be significantly affected by this alternative.

Summary of Unavoidable Impacts, Alternative C

Compaction and destruction or delayed growth of vegetation in areas of further geophysical exploration (green and brown trails).

Use of limited fresh-water resources for industrial purposes.

An unknown number of small spills (diesel fuel, oil antifreeze, and so forth) resulting from vehicle and equipment operation and causing destruction of vegetation, contamination of waters, or mortality of small food organisms.

Short-term, local increases in noise and other disturbances causing short-term, local displacement of some wildlife in areas with exploration activities.

Short-term, local disturbance of subsistence users from Kaktovik.

ALTERNATIVE D--NO ACTION

Under Alternative D, the general physical and environmental conditions on the 1002 area would essentially continue as they are at present. Fish, wildlife, and their habitats would respond to natural forces. The FWS would amend the comprehensive conservation plan (CCP) and, depending on the stage of refuge planning, the individual management plans for the entire refuge to include the 1002 area, which would be treated as an integral part of the entire Arctic National Wildlife Refuge.

Refuge planning has not been completed, so it is impossible to predict exactly what will be contained in the CCP and resultant management plans. The 1002 area has not yet been included as a part of this planning process, pending a management decision by the Congress. To fulfill the purposes for which the Arctic Refuge was established as outlined in ANILCA (sec. 302(2)), the management goals, at least until further defined by the CCP, would be: to maintain the existing availability and quality of refuge habitats with natural forces governing fluctuations in fish and wildlife populations and habitat change; to provide the opportunity for continued subsistence use of natural resources by local residents, in a manner consistent with sound natural resource management; and to provide recreational and economic opportunities compatible with the purposes for which the refuge was established.

Planning that would include the 1002 area could result in an increase in commercial activities, if found compatible, in the 1002 area as well as the rest of the Arctic Refuge. Public debate on petroleum related issues as a result of the ANILCA section 1002 program will result in greater awareness of the natural resource values of the Arctic Refuge. Thus, recreational use of the 1002 area would probably increase. The FWS permits activities on National Wildlife Refuges insofar as they are compatible with the purposes for which each refuge was established (the National Wildlife Refuge Administration Act Public Law 89-669, 16 U.S.C. 668 dd-ee and ANILCA section 304(b)). Infrastructure associated with offshore developments could be permitted within the 1002 area provided it (1) did not lead to development and production from the 1002 area and (2) was found compatible with refuge purposes. Some minor compatible surface geology studies could be possible.

Major long-term benefits would accrue to fish and wildlife as well as their habitats from management of the 1002 area under this alternative. Activities such as sport hunting and fishing or other recreational uses, or activities conducted for scientific studies, would result in negligible adverse effects on all species and resources discussed in previous alternatives.

~ In accordance with the terms of ANILCA Section 1003 and the Chandler Lake Agreement, development and production could not occur anywhere on the Arctic Refuge or on those lands owned by KIC/ASRC which lie within the

refuge boundaries unless the Congress enacted legislation specifically designed to open ASRC lands to these activities. Further exploration could not occur within the 1002 area without action from the Congress. Production of the estimated recoverable 3.2 billion barrels of oil would not occur. ~

~ Socioeconomic and sociocultural changes would be expected to continue in the manner and pace in which they now occur. There would be no (or few) new job opportunities, little increased cash flow, and little change in subsistence use so long as no infrastructure associated with offshore development were built on the 1002 area. ~

~ **Alternative-Energy Sources in Lieu of Development of the 1002 Area** ~

If the Congress took no action to open all or a part of the 1002 area to oil and gas leasing, future domestic oil production would be reduced. This could necessitate escalated imports of oil and gas, and/or require development of alternate-energy sources to replace the energy resources expected from the 1002 area.

The hydrocarbon potential of the 1002 area could contribute significantly to the region's and the Nation's energy supply; if the 1002 area were unavailable for development, the following actions or energy sources might be used as substitutes:

- Energy conservation
- Conventional oil and gas supplies
- Coal
- Nuclear power
- Oil shale
- Tar sands
- Hydroelectric power
- Solar energy
- Imports
- Geothermal energy
- Other energy sources
- Combination of alternatives

The following discussion of these alternative sources is excerpted and adapted from standard appendix matter in U.S. Minerals Management Service (MMS) EISs on proposed Outer Continental Shelf (OCS) oil and gas lease sales. For more detailed information, see "Energy alternatives--A comparative analysis" (University of Oklahoma, 1975; prepared for BLM by the Science and Public Policy Program, University of Oklahoma) and "Energy security--A report to the President of the United States" (DOE, 1987).

Energy conservation. Vigorous energy conservation warrants serious consideration. Several studies have suggested that Americans could enjoy the same standard

of living and yet use 30-50 percent less energy than currently being consumed. Existing conservation programs include education, research and development, regulation, and subsidies.

Residential and commercial sectors of the economy are often characterized as inefficient energy consumers. Inadequate insulation, inefficient heating and cooling systems, poorly designed appliances, and excessive lighting are often cited. Reductions in consumption beyond those induced by fuel-price increases could be achieved by new standards on products and building methods and/or subsidies and incentives. Excessive consumption is also evident in industry, where energy-inefficient work schedules, poorly maintained equipment, equipment with extremely low heat-transfer efficiencies, and unrecycled heat and waste materials are commonplace.

Transportation accounts for approximately 25 percent of nationwide energy use. Automobiles account for the bulk of all passenger movement in the Nation, and use more than twice as much energy per passenger mile as buses do. Short-term and midterm conservation measures--consumer education, lower speed limits, lower fares and service improvements on public transit, and rail-freight transit--may achieve considerable energy savings.

Other policies which could encourage fuel conservation in transportation include standards for more efficient automobiles and incentives to reduce miles traveled. An important development in fuel economy could be modification of the standard internal-combustion engine. Although such an engine is in the advanced stages of development, further study is necessary before an acceptable engine can be designed.

The environmental effects of a vigorous energy conservation program will be primarily beneficial. The nature and magnitude of these effects depend on whether there is a net reduction in energy use or whether the reduction is accomplished through technological change and substitutions. For the former, the net effects will mean fewer pollutants such as carbon dioxide, hydrocarbons, nitrous oxides, sulfur oxides, and particulates. Even with projected increases in conservation, the Department of Energy (DOE) estimates that energy demand will remain stable through this century. Thus, some means is needed to compensate for projected decreases in production (DOE, 1987).

Conventional oil and gas supplies. Between 1955 and 1969, the United States slightly increased amounts of proven oil reserves to about 30 billion barrels. The Prudhoe Bay discovery in 1970 raised the amount to 40 billion barrels, but reserves have been declining ever since. Since 1970, new oil discoveries have replaced less than half of production. Current estimates of U.S. oil and gas reserves are presented in Chapter VII of this report/LEIS.

Substituting directly for possible production from the 1002 area would require a combination of other onshore and OCS production and increased foreign imports.

Onshore oil production in the lower-48 States would entail environmental impacts such as land subsidence, soil sterilization, and disruption of existing land-use patterns. Equipment failure, human error, and blowouts also may impair environmental quality. Moreover, poor well construction, particularly in older wells, and oil spills can pollute ground and surface water.

Given the fact that onshore supplies are dwindling, users of hydrocarbons would have to continue their reliance on the OCS and foreign imports for needed oil and gas. The decline in these supplies, even with energy conservation, could mean industrial shutdowns, increased unemployment, higher consumer prices, and a lowered standard of living.

Coal. Coal is the most abundant energy resource in the United States; proven domestic reserves are estimated at 438 billion short tons. This constitutes more than one-quarter of the known world supply, 80 percent of proven U.S. fuel reserves, and 130 times the energy consumed in 1980. Ultimately recoverable reserves are estimated at 3.9 trillion short tons. Since 1974, domestic coal consumption has increased by almost 50 percent, or the energy equivalent of almost 2.3 million barrels of oil per day (DOE, 1987, p. 167). U.S. coal consumption is expected to continue expanding.

Due to its relative price advantage over other fuels, competitive market structure, and large resource base, coal consumption and production are expected to increase; but the rate of increase is uncertain mainly because there is considerable uncertainty about the volume of U.S. coal exports (DOE, 1987, p. 168). Coal may once again become the primary domestic-energy source. Synfuels from coal also will be important.

Although domestic coal reserves could easily replace the energy expected to be realized from developing the 1002 area, serious limitations to coal development exist. In many uses, coal is an imperfect substitute for oil or natural gas. In other cases, coal production and use are restricted by government constraints; limited availability of low-sulfur deposits; inadequate mining, conversion and pollution-abatement technology; and the hazardous environmental effects associated with coal extraction and coal-fired generation of electricity.

The Powerplant and Industrial Fuel Use Act of 1978 was designed to reduce petroleum and natural gas consumption and to encourage greater use of coal and alternative fuels. The Act prohibits new electric powerplants and large industrial boilers (and existing ones after 1990) from consuming oil or natural gas as a primary fuel source unless an exemption is granted.

Although U.S. coal resources are very large, there is some geographic dislocation, as with other extractable mineral fuels. Most low-sulfur coal is west of the Mississippi River or in Alaska, far from industrial areas. Also, much of the western coal is in arid or semiarid areas where scarcity of water could constrain development. If an alternative to oil production from the 1002 area is greater reliance on coal, mining might increase in the Western States.

Combustion of coal results in various emissions, notably sulfur dioxide and particulates. Using coal instead of oil produced from the 1002 area would increase these pollutants. Technology to control these emissions is available but is not widely applied, because emission-control devices for coal-burning plants are expensive to install and maintain. The sulfur content of eastern coal varies considerably, but approximately 65 percent of the developed resources have a sulfur content exceeding 1 percent. Any large-scale shift to coal would require relaxation of emission regulations or improvement of technologies to convert coal to gaseous or liquid fuels.

The primary effect of surface coal mining is disruption of the land. This affects local flora and fauna and water quality because of erosion and mine runoff. Reclamation is difficult in the Western States, where water for revegetation is scarce. Other problems are acid-mine-water drainage, leachings from spoil piles, processing waste, and disturbances caused by access and transportation. Surface mining conflicts with other uses such as agriculture, recreation, water, and fish and wildlife habitat.

Underground mining also affects land and water quality. Impacts on the land result from subsidence, waste disposal, access, and transportation. Subsidence can destroy structures, cause landslides and earthquakes, and disrupt ground-water circulation. The amount of subsidence and potential surface disruption can be controlled by mining methods.

Water quality is diminished by processing waste and drainage of acid-mine-water into surrounding areas. Waste piles can be replaced in the mine and entrances sealed, a practice which also minimizes subsidence. Other pollution problems, associated with road and coal dust and the like, are minimal and easily controlled.

The major coal transportation systems (rail, truck, barge, conveyor, and pipeline) all have some adverse environmental effects: air and noise pollution, safety hazards, land-use conflicts, trash-disposal problems and esthetic damage. A coal slurry pipeline requires large supplies of water that must adequately be disposed of at the delivery end. Water availability is a problem in many areas of the United States, especially in the West where energy resource requirements compete with existing commercial and private users.

Coal conversion. Technology to convert coal into gaseous and liquid hydrocarbons exists, and several relatively low-capacity commercial plants exist in various parts of the world. But few cost-effective advanced technologies are beyond the pilot-plant stage. Numerous problems must be solved before commercial development of synthetic fuels from coal can proceed. The cost effectiveness will depend on prices of other fuels, primarily oil and natural gas.

The Energy Security Act of 1980 created the U.S. Synthetic Fuel Corporation to provide financial assistance to the private sector for commercial synthetic fuel projects. Synthetic oil and gas could contribute substantially to energy supplies by the year 2000. The most important contributions would be high-BTU gas from coal, synthetic crude oil from oil shale, and coal liquefaction. The success of these sources will depend on developing technology, environmental effects, and the cost of conventional oil and gas.

Coal gasification. Gaseous fuels with low, intermediate, or high energy content can be produced. The environmental effects of coal gasification are those of mining plus those from production. Gasification processes have lower primary efficiency than direct coal combustion; more coal has to be gasified to reach an equivalent BTU output. Effects on water from processing can be minimized by recycling and evaporation. The large inputs of water required for some of the technologies create potential for conflicts in water-short areas. For example, one process (Koppers-Totzek gasifier) requires 463,000 gallons per day to process 10,570 tons of coal.

Air pollution could include emissions of sulfur dioxide, particulates, nitrous oxides, hydrocarbons and carbon monoxides. Land effects result from solid-waste disposal plus land use for the plant, coal storage, and cooling sands, and so forth. Solid wastes include ash, sulfur, and minute quantities of some radioactive isotopes.

Coal liquefaction. Liquefied coal is expected to replace conventional crude oil as the major source of liquid fuel and provide 10 percent of total domestic energy consumption by 2020. As with coal gasification, production of liquid fuels from coal requires either addition of hydrogen or removal of carbon from the compounds in the coal. Catalytic conversion is in commercial operation; other processes are under development. The available technologies have a recovery rate of 0.5 barrel to 3 barrels of oil per ton of coal processed.

Again, the effects of liquefaction will be those resulting from mining and from processing plants. Waste effluents from liquefaction plants could contain phenols, solids, oil, ammonia, phosphates, and so forth. Air pollution could result from particulates, nitrous oxides, sulfur oxides, and other gases. Solid wastes would be mostly ash. If liquefaction plants were sited near mine openings, residue could be buried in the mines with little effect.

Nuclear power. The predominant nuclear system in the United States is the nuclear fission process that uses uranium-dioxide-fueled, light-water-moderated and cooled nuclear powerplants.

Nuclear-power development has encountered delays in licensing, siting, and environmental constraints as well as manufacturing and technical problems. Future capacity will be influenced by the availability of plant sites, licensing considerations, environmental factors, nuclear-fuel costs, rate of development of reactors, and capital costs.

Domestic uranium resources are probably plentiful. Ultimately recoverable reserves are estimated to exceed 6,800 million short tons, and large areas are unexplored. Twenty-one million short tons were consumed in 1980 domestic nuclear-energy production. Nuclear energy may provide up to 13 percent of total domestic energy consumption in 2020. Nuclear energy is now second only to coal in supplying electricity. Without nuclear energy, the demand for oil and other substitutes would be far higher. Reducing oil demand has lessened upward price pressures and limited OPEC's influence on the global oil market. If oil alone had to replace existing nuclear capacity, most of the world's excess oil production capacity would vanish (DOE, 1987, p. 183).

Although nuclear plants do not emit particulates or gaseous pollutants, the potential for serious environmental problems exists. Some airborne and liquid radioactive materials are released during normal operation; the amounts are very small, and potential exposure is less than the average level of natural radiation exposure. The probability of harmful radioactivity released from accidents is very low.

Nuclear plants use essentially the same cooling process as fossil-fuel plants and thus share the problem of heat dissipation from cooling water. Light-water reactors require larger amounts of cooling water and discharge greater amounts of waste heat to the water than comparably sized fossil-fuel plants. Effects are often mitigated by using ponds or cooling towers.

Low-level radioactive wastes from operation of a nuclear plant must be collected, placed in protective containers, and shipped to a federally licensed storage site for burial. High-level wastes created within the fuel elements remain until the fuel elements are processed. Currently, spent fuel is stored at NRC-licensed facilities.

Uranium mining affects land, water, and air quality. Mining operations for uranium and coal are similar, but the nature and distribution of uranium deposits mean "lesser" effects, although radioactive tailings cause unusual problems for disposal, the environment, and human health.

Oil shale. Oil shale is a fine-grained, sedimentary rock which, when heated, releases a heavy oil that can be upgraded to synthetic crude oil. The technology exists, and the resource base for shale is very large, perhaps as

much as 360 billion barrels. Large areas of the United States are known to contain oil-shale deposits, but those in the Green River Formation in Colorado, Wyoming, and Utah have the greatest commercial potential.

Oil-shale development poses serious environmental problems. With surface or conventional underground mining, the extracted ("spent") shale occupies a larger volume than the original in-place material. Disposing of the huge quantities of spent shale is very difficult. Revegetation in an area of oil-shale development is difficult and may take more than 10 years. In-place processing avoids many environmental hazards.

Air pollutants from mining come from dust and vehicular traffic. These will be predominantly particulates, followed by nitrous oxides and carbon dioxide, with minimal amounts of hydrocarbons, sulfur oxides, and aldehydes. Air pollutants from processing vary with the technology used.

Mining oil shale requires little water, either for operations or for reclaiming solid wastes. Water pollutants are considered to be negligible unless saline water is encountered and has to be disposed of. The processing (retorting) operations of oil shale consume large quantities of water and generate large amounts of waste water which can be treated and reused. Therefore, water pollution presumably is not a problem outside the complex. The limited availability of input water could lead to resource-use conflicts.

Solid waste comprises the greatest problem in oil-shale processing. The volume of waste is greater than the volume of input oil shale. Therefore, backfilling does not provide sufficient disposal space.

Tar sands. Tar sands are deposits of porous rock or sediments that contain hydrocarbon oils (tar) too viscous to be extracted by conventional methods. Canada has developed large-scale production efforts, but U.S. ventures have been minor. U.S. resources are concentrated in Utah; some potentially commercial quantities occur in California, Kentucky, New Mexico, and Texas. Tar can be recovered either from sands mined on the surface or underground, or by direct underground extraction of the oil without mining. Recovery is followed by processing, upgrading to synthetic crude, and refining. Ultimately recoverable reserves may be 100 billion barrels, including other heavy oils.

Surface mining produces residuals, modifies topography, moves large amounts of overburden, creates dust and vehicle emissions, and causes water pollution. Reclamation can minimize some effects. Residuals are similar to those of coal. The effects of processing tar sands are similar to those of oil shale: solid tailings from extraction, cooling water and blowdown streams, thermal discharges, and off-gases. Under controlled conditions, these residuals can be minimized. Underground extraction without mining can result in thermal additions, contamination

of aquifers, surface spills, surface-earth movements, noise pollution, and emission of gases.

Hydroelectric power. Many of the major hydroelectric sites operating today were developed in the early 1950's. Then, hydroelectric plants supplied as much as 30 percent of the electricity produced in the United States. From 1970 to 1980, hydroelectric-power production fluctuated between 220 billion and 300 billion kilowatt-hours, about 4 percent of total U.S. energy production. Hydroelectric power will represent a declining percentage of total U.S. energy mix for these reasons: high capital costs, land-use conflicts, environmental effects, competitive water use, and flood-control constraints. Sites with the greatest production capacity and lowest development costs have already been exploited.

Construction of a hydroelectric dam represents an irreversible commitment of the land resource beneath the dam and lake. Flooding eliminates wildlife habitat and prevents other uses such as agriculture, mining, and river recreation.

Hydroelectric projects do not consume fuel or generally cause air pollution. Water released from reservoirs during summer months may change ambient water temperature and lower the oxygen content of the river downstream, adversely affecting fish. Fluctuating reservoir releases during peak-load operation may also adversely affect fisheries and downstream recreation.

Screens placed over turbine intakes reduce fish kill, but not kill of small organisms. Fish may die from nitrogen supersaturation, which results when excess water escapes from the draining reservoir. High nitrogen levels in the Columbia and Snake Rivers pose a threat to the salmon and steelhead resources of these rivers. Other adverse effects to water quality include possible saline-water intrusion into waterways and decreased ability of the waters to accommodate waste discharges.

Solar energy. Application of solar energy must take into account several factors. Solar energy is a diffuse, low-intensity source; only a small portion of the potential energy is used. Its intensity varies continuously with time of day, weather, season, and geographic location. Among the potential applications of solar energy are thermal energy for buildings, renewable clean fuel sources, and electric power generation. Solar-energy-collection systems are now commercially available nationwide. In some locations passive solar systems can supply up to 40 percent of the heating requirements for residences and small commercial buildings. Active solar systems are not yet able to compete broadly with conventional energy systems.

Effects of solar energy are relatively minimal, except for wide-scale land-use commitments. Due to the low density of energy, large areas are necessary for the collectors. The only other area of concern is thermal pollution from solar-electric-power generation, where heat

has to be collected and transferred to a generator. Some localized thermal pollution may result. Because solar collectors operate only intermittently, the energy must be stored, or backup fossil-fuel plants must be built.

Oil imports. OPEC probably will control most of the world's oil production for the remainder of the century, due mainly to the short-term inelasticity of the supply of substitutes; it may set prices based on factors besides price/cost relationships. Thus, the less dependent the U.S. is on OPEC, the less vulnerable it is to large, erratic price swings. Imports from the Middle East also bring problems of stability of supply, balance of payments, and currency-exchange rates.

The United States will probably remain dependent on imported energy throughout this century. As the 1970's showed, political situations in the Middle East could lead to major disruptions in supply or huge price increases. Under the threat of renewed embargo, American productivity and policy could become subservient to foreign influence, having both economic and security implications. On a more subtle level, political alignments and policies of the United States could become tied to those of foreign oil powers.

The primary environmental hazard of increased oil imports is the possibility of oil spills. Worldwide, an insignificant amount of the total volume of transported oil is spilled in tanker accidents. But a single incident such as the breakup of the Torrey Canyon in 1967 or the Amoco Cadiz in 1978 can have disastrous results. Spill rates are higher for foreign tankers than for U.S. tankers. Petroleum imports tend to be refined product, which is more toxic than crude.

Natural-gas imports. Imports of natural gas via pipeline have come mainly from Canada; small amounts come from Mexico. In 1980, imports from Canada were 881 billion cubic feet, about 4.4 percent of the total natural gas used in the United States, and about 33 percent of Canada's natural-gas production. The natural-gas import situation is uncertain owing to the disparity between prices for natural gas and alternative fuels in this country, the price of crude oil in world markets, and overregulation of domestic natural gas production, transport, and use.

The environmental effects of gas imports derive mainly from the possible increased use of land for pipeline construction. A further effect is the risk of explosions and fires.

Liquefied-natural-gas (LNG) imports. Large-scale shipping of LNG is relatively new. Several LNG projects are now under consideration on the Pacific, Atlantic, and Gulf Coasts. The costs of liquefying and transporting natural gas, other than overland by pipe, are high.

The environmental effects of the LNG imports arise mainly from tankers; terminal, transfer, and regasification facilities; and land transportation. The major hazard of

handling LNG is the possibility of fire or explosion during transportation, transfer, or storage. Receiving and regasification facilities require shoreline locations and channel dredging.

Geothermal Energy. Geothermal energy is primarily heat energy from the interior of the Earth. The major types of geothermal systems are hot-water, vapor-dominated or geopressured reservoirs, and hot-dry-rock systems. Geothermal energy can be used for space heating, industrial processing, and other nonelectric uses. Geothermal-electric generating plants are smaller than conventional plants and require a greater amount of steam to generate an equal amount of energy. Geothermal energy currently accounts for less than 1 percent of total United States energy production.

The greatest potential for geothermal energy in the United States is found in the Rocky Mountain and Pacific regions; some potential exists in the Gulf Coastal Plain of Texas and Louisiana. The Geysers field in California, the most extensively developed source of geothermal energy in the United States, has been producing power since 1969. Exploration is underway in the Imperial Valley, Mono Lake, and Modoc County, California.

Various gases are associated with geothermal systems. These gases include ammonia, boric acid, carbon dioxide, carbon monoxide, and hydrogen sulfide. They may pose health and pollution problems; but adverse air-quality effects are generally less than those associated with fossil-fuel plants. Associated saline waters must be disposed of and isolated from ground water. Land-quality problems stem from disturbance due to construction of related facilities and possible ground subsidence which, in turn, can cause structural failures and loss of ground-water storage capacity.

Other energy sources. The high cost and rapidly shrinking reserves of traditional energy fuels have encouraged research into new and different sources, such as tidal power, wind power, and ocean thermal-gradients. Some of these sources have been known for decades, but high costs and technical problems have prevented their widespread use. By 2020 these sources may account for 13 percent of total domestic energy consumption. Environmental effects are difficult to assess, because much research and development must precede operational-scale systems for testing and evaluation.

Combination of alternatives. A combination of energy sources could be used to attain an energy equivalent comparable to the estimated crude oil production from the 1002 area. Assuming favorable technology and economics, the most likely domestically available energy alternatives for oil are probably: coal, oil shale, tar sands, and biomass to produce synthetic liquids; nuclear energy and coal to compete for the utility market; and renewables to supply part of total energy requirements. The mix will depend on multiple factors: identification of resources; research and

development; technology advances; rate of economic growth; economic climate; changes in lifestyle and priorities; capital investment decisions; energy prices; world oil prices; environmental priorities; government policies; and availability of imports.

Conclusion. The energy system of the United States is very complex, and its energy mix is difficult to project in the long term. Coal and nuclear energy are the only technically proven, large-scale sources of future electricity supply today that are viable alternatives to oil and natural gas (DOE, 1987, p. 187). No single choice among alternative energy sources stands out, nor does development of one source that precludes development of others. Understanding the extent to which alternate sources they may replace or complement production from the 1002 area requires reference to the total national-energy picture. Relevant factors are:

- (1) Historical relationships indicate that energy requirements will grow in proportion to the gross national product.
- (2) Energy requirements can be constrained to some degree through the price mechanisms in a free market or by more direct constraints. One important type of direct constraint operating to reduce energy requirements is through the substitution of capital investment in lieu of energy (insulation to save fuel). Other potentials for lower energy use have more far-reaching effects and may be long range in their implementation--rationing, altered transportation modes, and major changes in living conditions and lifestyles. Even severe constraints on energy use can be expected to only slow, not halt, the growth in energy requirements.
- (3) Energy sources are not completely interchangeable. For example, solid fuels cannot be used directly in internal combustion engines.
- (4) The principal competitive interface between fuels is in electric powerplants. The full range of flexibility in energy use is limited by environmental considerations.
- (5) Regulation of oil and gas prices lowered the price below the product level that refiners (and consumers) paid for domestic oil, and prevented domestically produced oil from competing with imported oil. This Nation's inability to adjust to world energy prices has led to underproduction of domestic oil, overconsumption of imports, and disincentives to alternative energy.
- (6) Much of the research and development is directed toward energy conversion--more efficient nuclear reactors, coal gasification and liquefaction, liquefied natural gas (LNG), and shale retorting, among others.

The 1002 area offers the greatest potential to add to our Nation's oil and gas production. In time of crisis there may be no opportunity to plan and conduct orderly, environmentally sound exploration and development of the 1002 area. Pressure for rapid development would be extreme.

ALTERNATIVE E--WILDERNESS DESIGNATION

If the Congress were to designate the 1002 area as Wilderness, an extensive continuum of undisturbed arctic environment in the United States would be preserved, extending from the crest of the Brooks Range to the Arctic Ocean. Under the Wilderness Act (P.L. 88-577), the FWS would manage this area to maintain wilderness resources and values, preserve the wilderness character of the biological and physical features, and provide opportunities for research, subsistence, and recreation. Loss or alteration of fish and wildlife habitats would occur in response to natural forces (population cycles, weather, predators, disease, etc.). None of the exploration and oil development, production, or transportation activities described in Alternatives A, B, and C could occur. Government research concerning the Alaska Mineral Resource Assessment Program (ANILCA section 1010) could continue. In accordance with the terms of the Wilderness Act and ANILCA, future petroleum development would be prohibited anywhere on the Arctic Refuge, as well as within the KIC/ASRC lands. Production of the estimated recoverable 3.2 billion barrels of oil would be forgone.

Previous surface geology activities had no apparent adverse effects on fish, wildlife, and wilderness values. Such activities would be permitted as a prior existing use for scientific purposes if the 1002 area were designated as wilderness. By using similar protective stipulations, effects on fish, wildlife, and wilderness values would be negligible. The opportunity for economic change related to petroleum revenues, jobs, and other stimuli described in Alternatives A, B, and C would be lost.

~ Hunting, fishing, and trapping would be allowed. Traditional modes of access used for subsistence will be permitted. It will be necessary to determine what these modes of transportation are by communities using the 1002 area for subsistence. Present sociocultural changes would not be affected by this alternative. ~

Except for exploration, further petroleum development on lands owned by KIC and ASRC would be precluded under the provisions of section 1003 of ANILCA and the Chandler Lake Land Exchange Agreement between the United States of America and ASRC, unless the Congress made special provisions in its wilderness designation for the 1002 area.

The environmental effects of obtaining energy from substitute sources, rather than from the Arctic Refuge, would be the same as those discussed under Alternative D.

~ CUMULATIVE EFFECTS ~

The CEQ regulations for implementing the National Environmental Policy Act (NEPA) require that consideration be given in an environmental impact statement (EIS) to the cumulative effects "on the environment which result from the incremental impacts of the [proposed] action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7).

Several elements should be present before a potential action is considered in an assessment of cumulative effects: (1) the proposed action includes application(s) for a license, permit, or other regulatory approval; (2) the proposed action has been determined to be a project which may significantly affect the environment; (3) the proposed action is sufficiently defined in terms of construction and operations characteristics from which potential effects can be determined in the absence of NEPA review; (4) the geographic area of influence of the proposed action is contiguous to or overlaps the region that is the subject of environmental assessment in this proposal; and (5) there is a substantial commitment to execute the proposed action.

Projects described in table VI-8 range from those that already exist to those that could occur at some point in the more distant future. Only existing projects conform to the criteria listed above. The cumulative effects of those projects have been considered throughout this assessment. The Chukchi Sea region includes onshore lands west of the Colville River and offshore areas between the Beaufort Sea OCS (Outer Continental Shelf) Planning Area and the Bering Strait. Although development in this region is somewhat removed from the 1002 area, it may affect some of the resources analyzed in this LEIS. The mid-Beaufort Sea region includes the onshore areas between the Colville and Canning Rivers, all State submerged lands between Barrow and the Canning River, and the Beaufort Sea OCS Planning Area. The eastern Beaufort Sea region is defined as the area east of the Canning River.

One consideration in determining whether to open the 1002 area for oil and gas leasing is the potential for regional adverse effects related to cumulative incremental losses and disturbance of arctic habitat. As described in Chapter II, the 1002 area, which comprises 1.55 million acres, is part of the larger Arctic Coastal Plain Province. Some of the wildlife populations within the refuge, including caribou, muskoxen, marine mammals, and migratory birds, have ranges that extend beyond the 1002 area. This section summarizes the potential cumulative effects of development within the coastal plain region from a programmatic aspect. Detailed analyses of potential cumulative effects generally are carried out as part of environmental assessments for specific lease sales.

Human activities within the 1002 area have been restricted to subsistence uses by local native communities, and limited military operations and natural resource surveys.

Some development has occurred in neighboring areas. Most notable are the oil production facilities at Prudhoe Bay, located within 50 miles of the northwest boundary of the 1002 area. Another operation, the Endicott Development Project, is current under construction 2.5 miles offshore between Prudhoe Bay and the Arctic Refuge. This project, which is expected to yield about 100,000 barrels of oil per day beginning in 1988, involves the construction of extensive facilities including a causeway, TAPS pump station, and base camp for 600 people. Other oil exploration activities have occurred on the North Slope and within the NPRA further to the west; however, hydrocarbon resources in these areas have not proved commercially recoverable.

Oil exploration and other types of development have taken place in nearby areas of Canada. During the late 1970's, the Dempster Highway was built through the Yukon Territory to Inuvik. Several exploratory wells were drilled within the Canadian part of the coastal plain, and extensive exploration activity has occurred within the Canadian Beaufort Sea and Mackenzie Delta region. The Gulf Canada Corporation recently proposed to start seasonal oil production in the Beaufort Sea by 1988 (Oil and Gas Journal, Feb. 2, 1987, p. 20). This development is expected to deliver 20,000-40,000 barrels of oil per day, with a minimum work schedule of 120 days per year. Ice-breaking barges would carry this initial production along the Alaska coast to a tanker transshipment point. Eventually, the company may propose an expanded year-round production schedule, which would involve construction of a new Mackenzie Valley pipeline to Alberta.

Further leasing of oil and gas resources within the U.S. Outer Continental Shelf adjacent to the Arctic Refuge is under consideration (table VI-8). The Department of the Interior has proposed additional areas within the Beaufort and Chukchi Seas be made available for oil and gas development (Sale 97, U.S. Minerals Management Service, 1986; Sale 109, U.S. Minerals Management Service, 1987). Development of these areas could potentially involve the construction of extensive offshore and coastal support facilities.

In addition to Federal leasing activity, the State of Alaska has had in the past, and expects to have in the future, substantial leasing in northern Alaska (table VI-8). Since 1964 the State has leased 3.6 million acres on the North Slope, in the Prudhoe Bay, Kuparuk, Milne Point, Endicott, and Lisburne areas. The State has also leased areas adjacent to the Arctic Refuge in the Point Thomson and Flaxman Island areas.

The State has proposed leasing an additional 34.9 million acres in its 5-year oil and gas leasing program between 1987 and 1991. Sale 50, proposed for June 1987, would lease 123,000 acres in Camden Bay adjacent to the Arctic Refuge. Sale 55 would lease 300,000 acres in 1988 north of the Arctic Refuge and to the west of Camden Bay. Sale 64 would lease 772,000 acres of the State lands

~ Table VI-8.--Major projects considered in cumulative-effects assessment. ~

[Adapted from U.S. Minerals Management Service (1987).]

Project name	General location	Developmental timeframe	Current status
Chukchi Sea region			
North Slope Borough Capital Improvements Program.	North Slope Borough.....	1983-1985+	Includes projects at villages, Prudhoe Bay and Kuparuk.
National Petroleum Reserve-Alaska.	Northwest Alaska, west of Colville River.	1944-1991	No commercial reserves have been discovered. In 1985, drilling began on areas leased under the DOI program. Annual lease sales are scheduled.
Arctic Slope Regional Corporation.	Primarily northwestern Alaska, south and west of NPRA.	1973 and thereafter.	Low-level exploration ongoing; no discoveries. Drilling up to three wells in Arctic Refuge.
Future State of Alaska Leasing.	35 km south of Barrow to Cape Beaufort and in Kotzebue Sound.	1987 and thereafter.	State Lease Sales 45, 53, 58 and 60 were included on the 1986 lease schedule. The State dropped these areas from the 1987 5-year lease schedule pending more favorable leasing conditions.
Future OCS Leasing			
a. Chukchi Sea	Offshore Chukchi Sea.....	1990 and thereafter.	Information for Sale 109 also would apply to future Sale 126 proposed for 1991.
b. Hope Basin.....	Kotzebue Sound and Chukchi Sea.	1991 and thereafter.	OCS Sale 133 is a frontier-exploration sale proposed for 1992.
Mid-Beaufort Sea region			
Trans-Alaska Pipeline	Prudhoe Bay to Valdez...	1973-1977	The 800-mile pipeline and related facilities occupy 42.4 km ² . Current flow rate is 1.7 million bbls/day.
Prudhoe Bay Unit oil production.	Prudhoe Bay onshore.	1965-2006	Peak production ongoing until 1987; declining thereafter.
Lisburne field.....	Prudhoe Bay Unit	1968-2017	Development of onshore portion is underway.
Kuparuk River field	Approx. 40 km west of Prudhoe Bay, onshore.	1970-2002	Phase I production began December 1981. Full-field water flooding began in 1986.
West Sak	Within Kuparuk River Unit.	1970-2015+	Pilot project completed. Development will not occur until oil prices improve and become more stable.
Endicott.....	19.3 km east of Prudhoe Bay offshore.	1977-2000+	Roads and islands are constructed. Pipeline should be completed by 1987.

Project name	General location	Developmental timeframe	Current status
Mid-Beaufort Sea region--Continued			
Milne Point.....	North of Kuparuk River Unit.	1970-2000+	Production began in 1985 and was suspended in 1986. Milne pipeline ties into the Kuparuk pipeline.
Discovered resources (oil fields and gas fields).	Mid-Beaufort Sea .....	.....	Until gas infrastructure is available, gas fields such as Point Thomson and Gubik will not be developed. Others such as Gwydyr Bay, Ugnu Sands, and Simpson Lagoon need either technological advances or increases in oil prices before they can be developed.
Seal Island.....	Beaufort Sea.....	1981-2014	Additional wells planned.
Previous State Sales	Uplands and offshore in Mid-Beaufort Sea region.	1983-2014	Seal Island and Endicott are primarily on State-leased land.
Previous Federal Offshore Lease Sales.	Barrow to Canada within 200-m isobath.	1981-2014	Exploration drilling underway.
Future OCS Leasing Beaufort Sea.	Offshore Beaufort Sea.....	1990 and thereafter.	Information for Sale 97 applies to future Beaufort Sea sales.
Future State of Alaska Leasing.	Offshore Beaufort Sea; onshore east of Prudhoe Bay Unit.	1986 and thereafter.	State Lease Sales 51, 52, 54, 57, 64 and 65 are both onshore and offshore. Little information is available. Sales 57 and 61 were dropped from the 5-year lease schedule in November 1986.

Eastern Beaufort Sea region

Canadian Beaufort Sea (ESSO, Dome, Gulf acreage).	Offshore Mackenzie Bay, Canada.	1973-2000+	Major discoveries subject to delineation. EIS on development and production completed, but no development announced yet.
Future State of Alaska Leasing.	Submerged lands between the Canning River and Demarcation Point.	1987 and thereafter.	State Lease Sales 50 and 55.

between the Sagavanirktok and Canning Rivers, just to the west of the Arctic Refuge.

The activities described above could eventually lead to a wide range of environmental effects. The construction of transportation, drilling, processing, and residential facilities, use of large volumes of water, and management of waste materials involve localized alteration of land cover and attendant losses in plant production and animal habitat. Some direct losses of resident animals, particularly among less mobile species, are likely. Habitat modification and loss or reduction of value in conjunction with noise and other disturbances are linked to changes in local habitat use patterns by some migratory species.

The cumulative impacts of possible activities in all the offshore areas and the 1002 area cannot be assumed to be

the sum of likely impacts in each of these areas. On the other hand, the probability that there will be a reduction in activity in areas on the North Slope which currently produce, or are about to produce oil, is much higher. This would lead to partial cancellation of some of the impacts.

Habitat loss and modification associated with past and potential development within the region could affect a number of wildlife populations of national interest. Of particular interest are potential cumulative effects on the Porcupine caribou herd and the Central Arctic herd, both of which range beyond the boundaries of the 1002 area. Some regional development activities, including those at Prudhoe Bay, have occurred within areas historically used for caribou calving. As discussed earlier in this chapter, post-development studies indicate an absence of calving

near the coast at Prudhoe Bay during 1976-85, possibly due to avoidance of the area by caribou. Despite apparent changes in distribution, the populations of both caribou herds have been increasing. At some point, however, incremental loss and modification of suitable calving habitat could be expected to result in population declines. Similarly, at some time, cumulative habitat loss within the region potentially could result in changes in distribution or population reductions of other species including muskoxen, wolves, wolverines, polar bears, snow geese, and arctic grayling.

The potential for and extent of specific adverse cumulative effects would have to be determined by future studies. The FWS has carried out an extensive program of baseline investigations on the biological resources of the 1002 area. In the event of oil exploration and development, followup areawide studies by the FWS and targeted studies related to specific oil operations could be useful in identifying changes in regional fish and wildlife populations.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

~ Oil and Gas Resources ~

The recoverable oil resource estimate used for the assessment in this chapter and for the scenarios in Chapter IV is the conditional mean recoverable figure of 3.2 billion barrels of oil (BBO). The estimates range from a low of 0.6 BBO at the 95-percent chance to a high of more than 9.2 BBO at the 5-percent chance. If the Congress elects to permit oil and gas development and production on the 1002 area of the Arctic Refuge and if exploration efforts are successful, the amount of development would be directly dependent upon the actual amount of economically recoverable reserves discovered. Those resources discovered and economically producible would be irreversibly committed to development.

Biological Resources

~ If species such as caribou and muskox did not readily habituate to development facilities and activities, and if suitable alternative habitats are not available, the expected impacts could be in terms of declines in population and overall herd vigor, and major changes in behavioral patterns due to disturbance and displacement. Many of these effects, though very long-term, would not be considered irreversible once the life of the producing fields in the 1002 area was over. ~

Placement of gravel pads for roadways, pipelines, airfields, processing facilities, housing, and other infrastructure under full leasing will cover slightly more than 5,000 acres of natural vegetation. Although there can be some flexibility in siting so that higher value habitats can be avoided, the affected vegetation may be considered an

irretrievable loss, because rehabilitation could take as much as 100 years in the harsh arctic environment. An additional 500 to 750 acres of the coastal plain may also be permanently altered as a result of gravel mining.

~ Longer oil production times would also increase the potential for oil spills and other toxic/contaminant accidents, the results of which are detailed in Alternatives A and B.

Approximately 20 acres of shallow subtidal marine bottom could be permanently altered by construction of docks and causeways at each port site. A causeway could also have permanent effects on nearshore temperature and salinity regimes and circulation, which in turn could alter species composition of planktonic and benthic organisms in the area affected or influenced by the causeway. Whether these populations would return to pre-project levels and composition following either deliberate removal of the causeway or natural erosion is problematical.

~ Social and Historical Resources ~

Irretrievable products of prehistoric culture such as archeological sites might be lost from looting and indiscriminate or accidental activity on known and unknown sites. Training of personnel and stipulations for the protection of such resources would reduce the level of those losses.

Traditional subsistence life styles would be irreversibly and irretrievably lost or altered with the introduction of widespread industrial activity and greater opportunities for a cash-based economy.

The wilderness character of the coastal plain would be irretrievably lost.

COMPARISON OF SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

Geological and geophysical investigations carried out in 1983-85, and other available information, have revealed geologic structures having the potential for containing oil and gas resources. If the Congress allows oil and gas production from the 1002 area, exploration will proceed and, if oil and gas resources are found in economic quantities, production will result. Though the structures appear highly favorable, there is no assurance that they do contain oil and gas. Nevertheless, based on favorable exploration results from the Prudhoe Bay oil field to the west and the Canadian Beaufort Sea and Mackenzie Delta oil fields to the east, the prospects are encouraging. Even with negative results, mid- to short-term changes caused by 10-15 years of exploration could occur before the area would be abandoned.

The short-term activities associated with further exploration of the 1002 area will lead to generally short-term displacement and disturbance of fish and wildlife resources and subsistence users as described in this chapter. If

further exploration indicates that the delineated structures are barren, production and transportation systems will not be needed--development efforts can be terminated, the lands reclaimed, and the area allowed to return as closely as possible to its current condition. In this case, few or no residual or long-term effects on wildlife populations of the area are expected. The wilderness attributes of the 1002 area will be affected for a longer time, but are eventually expected to generally recover.

~ Losses in fish and wildlife resources, subsistence uses, and wilderness values on the 1002 area would be the consequence of a long-term commitment to oil and gas development in the area. If economic prospects exist, the area would be committed to petroleum operations for a period of 30-90 years with an estimated 3.2 billion barrels of oil being produced during that period. It is expected that gas production from this area would be economic within two to three decades. However, successful oil and gas exploration would lead to industrial development having an infrastructure as depicted in Chapters IV and V. Also to be expected are pressure to use this area as a base for servicing exploration and development of the Outer Continental Shelf area to the north, and pressure on the Congress to open areas designated as wilderness in the Arctic Refuge to oil and gas exploration, depending on the location of actual discoveries. Moreover, an oil and gas development infrastructure in the 1002 area would be an impetus to development of State lands between the Canning River and the TAPS to the west. If the infrastructure also served potential offshore or other fields, it will add to the long-term commitment of this area to industrial use based on oil and gas development. ~

Commitment of the 1002 area to oil and gas development would provide the opportunity to extract the recoverable reserves to help meet projected national energy needs as fully described in Chapter VII.

~ Oil and gas development would result in long-term changes in the wilderness environment, wildlife habitats, and Native community activities currently existing, resulting instead in an area governed by industrial activities. These changes could include displacement and reduction in the size of the Porcupine caribou herd if intensive activities occur in its repeatedly used concentrated calving area, as well as throughout a large part of its postcalving, insect-relief, and foraging habitats. The amount of herd reduction, if any, and its long-term significance to herd viability is highly speculative. Relevant experience regarding the responses or adaptability of the PCH to such intensive activities is lacking. However, geography apparently limits the availability of suitable alternative calving or insect-relief habitats. The ability of the herd to calve successfully at even greater concentrations than at present in calving areas which would remain unaffected by oil and gas activities is unknown. Mitigation measures such as environmentally sensitive siting of facilities, time and area closures, and harvest restrictions can minimize some adverse effects on the PCH as well as on other fish, wildlife, and subsistence resources. ~

~ The wilderness character of the 1002 area would be lost, leaving the designated Arctic Refuge wilderness area east of the Aichilik River to the Canadian border, and the 3-million acre North Yukon National Park in Canada as the only remaining areas of preserved Arctic coastal plain ecosystems in North America. ~

~ Industrial development will also have a profound effect on the Native culture. Although it may provide jobs for a few members of the Kaktovik community, it will conflict with or hasten changes in life style from one of subsistence use dependent on the land to an industrial society with a cash-based economy. Increased educational and employment opportunities and greater health services may be benefits but only at the expense of traditional ways of life, community bonds, and cultural disorientation. ~

With authorization of oil and gas development, KIC and ASRC will have the opportunity to develop their oil and gas resources adjacent to the 1002 area, further speeding the modernization of local life styles. The tradeoffs involved are a subjective assessment: lost opportunities to pursue traditional cultural activities and subsistence life styles for employment opportunities and economic gains which may be unevenly distributed throughout the community. Acceptability of these potential changes will only be partly a local decision, relative to the extent to which the development of an industrial-commercial base in Kaktovik is pursued.

Local people can either encourage or discourage ancillary development servicing the oil and gas industry. During hearings for the previous 1002 area exploration program, Kaktovik residents expressed concerns that their opportunities to pursue a subsistence life style not be diminished, including desires that fish and wildlife resources not be reduced or displaced, yet that they be allowed to benefit from jobs or other economic opportunities available. Residents of Arctic Village and other Native communities utilizing caribou from the highly migratory PCH were critical of any impacts to their subsistence resources which could be caused by exploration. Views of Kaktovik or other villages regarding full development are unknown. The ASRC has publicly expressed its support for oil and gas development on both KIC/ASRC lands and the 1002 area. Congressional authorization of development would include authorization to develop oil and gas resources on the KIC/ASRC lands, which will add to effects on subsistence users and traditional lifestyles.

~ A decision to pursue oil and gas development on the 1002 area will result in tradeoffs. As much as 9.2 billion barrels of oil would become available to contribute to the Nation's energy needs and offset oil imports. On the other hand there could be a loss of a significant part of the PCH calving grounds and other habitats, continued expansion of muskoxen herds, staging habitats for internationally important migratory snow geese, and numerous other fish and wildlife habitats. Additional tradeoffs involved in

**SUMMARY OF EFFECTS FOR ALTERNATIVES A, B, C, D, AND E ON THE PHYSICAL,
BIOLOGICAL, AND HUMAN ENVIRONMENTS OF THE 1002 AREA**

	Alternative				
	A	B ¹	C	D ²	E
Physical environment					
Water	Major	Major	Minor	None	None
Gravel	Moderate	Moderate	Minor	None	
Air	Minor	Minor	Minor	None	None
Permafrost	Moderate	Moderate	Neg.	None	
Ambient noise	Major	Major	Minor	None	None
Biological environment					
Vegetation, wetlands, and terrain types	Minor	Minor	Neg.	Neg.	Neg.
Special terrestrial and aquatic environments	Neg.	Neg.	Neg.	Neg.	Neg.
Coastal/marine environment	Minor ³	Minor ³	Neg.	Neg.	Neg.
Caribou (PCH)	Major	Moderate	Neg.	Neg.	Neg.
(CAH)	Minor	Minor	Minor	Neg.	Neg.
Muskox	Major	Major	Minor	Neg.	Neg.
Moose	Minor	Neg.	Neg.	Neg.	Neg.
Dall sheep	Neg.	Neg.	Neg.	Neg.	Neg.
Wolf	Moderate	Minor	Neg.	Neg.	Neg.
Arctic fox	Minor	Minor	Neg.	Neg.	Neg.
Wolverine	Moderate	Moderate	Neg.	Neg.	Neg.
Brown bear	Moderate	Minor	Neg.	Neg.	Neg.
Polar bear	Moderate	Moderate	Minor	Neg.	Neg.
Seals/whales	Minor	Minor	Neg.	Neg.	Neg.
Ground squirrel/other rodents	Minor	Minor	Neg.	Neg.	Neg.
Snow goose	Moderate	Moderate	Neg.	Neg.	Neg.
Tundra swan	Minor	Minor	Neg.	Neg.	Neg.
Other geese/ducks	Minor	Minor	Neg.	Neg.	Neg.
Seabirds/shorebirds	Minor ⁴	Minor ⁴	Neg.	Neg.	Neg.
Peregrine falcon	Minor	Neg.	Neg.	Neg.	Neg.
Raptors	Minor	Minor	Neg.	Neg.	Neg.
Ptarmigan	Neg.	Neg.	Neg.	Neg.	Neg.
Passerines	Minor	Minor	Neg.	Neg.	Neg.
Fresh-water fish ⁵	Minor	Minor	Neg.	Neg.	Neg.
Coastal fish	Minor ⁶	Minor ⁶	Neg.	Neg.	Neg.
Human environment					
Human population	Moderate	Moderate	Neg.	Neg.	Neg.
Sociocultural	Major	Major	Minor	Neg.	Neg.
Subsistence	Major ⁷	Major ⁷	Minor	Neg.	Neg.
Native allotments	Major	Major	Minor	Neg.	Neg.
Land status and military	Neg.	Neg.	Neg.	Neg.	Neg.
Industrial	Major	Major	Minor	Neg.	Neg.
State/local political and economic	Major	Major	Minor	Neg.	Neg.
Public services/ facilities	Major	Major	Minor	Neg.	Neg.
Archeology	Neg.	Neg.	Neg.	Neg.	Neg.
Recreation, wilderness, and esthetics	Major	Major	Moderate	Neg.	Neg.

FOOTNOTES FOR TABLE ON FACING PAGE

¹Effects will generally be the same as for full leasing but over less area.

²Depending on final CCP.

³Oil spills and (or) cumulative developments could cause major impacts.

⁴Some local effects could be moderate.

⁵Includes Arctic char and grayling.

⁶Could be moderate with development of KIC/ASRC or offshore areas. Other than minor effects expected in vicinity of port sites, effects on coastal fish will be negligible. Effects could be major with an oil spill in fish habitats.

⁷For residents of Kaktovik.

developing coastal plain oil and gas resources include reduced air and water quality and industrial commitment of gravel and water resources. ~

~ Development will also significantly restrict the continuation of subsistence hunting by residents of Kaktovik. Arctic Village and other communities in Alaska and Western Canada dependent on migratory fish and wildlife populations of the 1002 area could experience some decline in subsistence opportunities. Finally, the wilderness value of the fragile and limited Arctic coastal plain ecosystem would be gone for a century or more. ~

~ Conversely, a decision to designate the 1002 area as wilderness while maintaining the long-term fish, wildlife, subsistence, and wilderness values would be done at a cost of a potential, but unconfirmed, estimated mean value of 3.2 billion barrels of oil and the economic and security benefits the Nation could achieve from production of that oil. ~

SUMMARY OF RECOMMENDED MITIGATION FOR THE 1002 AREA

Following is a summary of safety and environmental mitigation measures that could be recommended for various phases oil and gas exploration, development, production, and transportation activities on the 1002 area.

Mitigation measure	Results
1. Limit oil exploration, except surface geology studies, to November 1-May 1 (exact dates to be determined by Refuge Manager). Cease exploration activities and remove or store equipment at an approved site by May 15. Local exceptions may be made.	Will limit disturbance to periods when most fish and wildlife species are absent.
2. Consolidate, site, construct, and maintain facilities and pipelines to minimize effects on sensitive fish and wildlife habitats and species. Locate nonessential facilities outside concentrated caribou calving areas.	Will avoid or minimize disturbance in, or loss of, environmentally sensitive areas and allow free passage and natural movement of fish and wildlife.
3. Design all bridges and culverts to handle at least 50-year flood events.	Will prevent damage and disturbance of fish habitats.
4. Use ice or gravel-foam-timber pads, where feasible.	Will reduce gravel requirements and acres of habitat modified.
5. Prohibit: gravel removal from active stream channels on major fish-bearing rivers; winter water removal from fish-bearing waters, or springs and tributaries feeding into fish-bearing waters; spring, summer, or fall water removal from fish-bearing waters to levels that will not easily pass fish or maintain quality rearing habitat.	Will minimize disturbance to fish and degradation of fish habitats.
6. Elevate pipelines to allow free passage of caribou or place ramps or bury as feasible.	Will allow migration and other movements of caribou and large mammals.
7. Separate roads and pipelines 400-800 feet, depending on terrain, in areas used for caribou crossing.	Will enhance crossing of linear structures by caribou and other mammals.

Mitigation measure	Results
8. Construct docks and causeways so that fish movements are not impeded and lagoon water chemistry is basically unchanged.	Will provide for fish and marine mammal movement and lessen degradation of near-shore marine habitat.
9. Avoid construction in coastal areas near river systems with topographic relief or bluffs; otherwise, minimize construction activities along the coast through the denning period, approximately mid-March. Minimize activities along the coast during late October-early November when polar bears come ashore to den.	Will reduce disturbance to polar bears, and prevent destruction of potential bear den and raptor nest sites.
10. Restrict surface occupancy in the zone from the coastline inland 3 miles to marine facilities and infrastructure essential to move inland beyond the restricted zone; drill pads and production facilities could be allowed within the zone 1.5 to 3 miles from the coast on a site-specific basis.	Will permit caribou use of coastal insect-relief habitat and reduce disturbance of nesting waterfowl and other species.
11. Prohibit surface occupancy in the Sadlerochit Spring Special Area (pl. 1A).	Will prevent degradation of a unique environment and prevent loss of water essential for fish overwintering.
12. Minimize surface occupancy in immediate vicinity of areas identified as supporting <u>Thlaspi arcticum</u> . Include information on identification and need for avoidance of <u>Thlaspi arcticum</u> in all environmental orientation briefings.	Will prevent destruction of <u>Thlaspi arcticum</u> .
13. Use bear-proof fencing around certain facilities; develop solid waste management plans; incinerate putrescible waste daily; prohibit wildlife feeding; institute employee education programs as appropriate.	Will minimize bear/human confrontations, and reduce attraction of and increases in scavenger populations.
14. Inventory project areas for cultural resources, evaluate resources, and implement mitigation to avoid or minimize impact.	Will preserve cultural resources (archeological and historic sites) to the maximum extent possible.
15. Prohibit off-road vehicle use within 5 miles of all pipelines, pads, roads, and other facilities, except by local residents engaged in traditional uses or if otherwise specifically permitted.	Will minimize disturbance to wildlife, reduce destruction of vegetation, and permit migration of large mammals.
16. Establish time and area closures or restrictions on certain surface activity such as exploration, vehicle movements, and other activity that can be reasonably rescheduled, in areas of wildlife concentration during muskox calving, April 15-June 5; caribou calving, May 15-June 20; caribou insect harassment, June 20-Aug. 15; snow goose staging, Aug. 20-Sept. 27; and fish overwintering and spawning.	Will protect species from disturbance during critical periods.
17. Limit use of development infrastructure, roads, and airstrips to persons on official business.	Will reduce disturbance and human/wildlife interaction.
18. Reinject drilling muds, cuttings, and other wastes where geologically feasible. Remove hazardous wastes off refuge to an approved disposal site.	Will minimize areas needed for reserve pits and reduce potential for contaminant spills.

Mitigation measure	Results
19. Close areas within 3/4 mile of high-water mark of specified water courses to permanent facilities and limit transportation crossings. Gravel removal may occur on a site-specific basis.	Will protect riparian habitat and reduce stream pollution and disturbance in an important and limited habitat.
20. Prohibit use of explosives or other noisy activities within 2 miles of raptor nest sites April 15-August 31 (June 1 if nest is unoccupied), unless specifically authorized by the FWS.	Will protect nesting peregrine falcons and other raptors from disturbance.
21. Prohibit ground level activity, permanent facilities, and long-term habitat alterations (material sites, roads, and airstrips) within 1 mile of known peregrine or other raptor nest sites April 15-August 31 (June 1 if nest is unoccupied) unless specifically authorized.	Will protect nesting peregrine falcons and other raptors from disturbance.
22. Survey suitable habitat annually to locate nesting peregrines and other raptors.	Will avoid conflicts between development and nesting raptors.
23. Establish no-activity zone of at least 1/2 mile around any confirmed polar bear den.	Will prevent disturbance during denning.
24. Close area within 5 miles of development and associated infrastructure to hunting, trapping, and discharge of firearms, except for subsistence uses only, on a site-specific basis, where there will be major effects on those uses.	Will increase public safety and reduce direct mortality of caribou, muskoxen, bears, and waterfowl; lower disturbance and increase the likelihood of habituation by species encountering development; however, will result in negative effects to subsistence uses of some areas.
25. Develop and implement plans for control, use, and disposal of fuel and hazardous wastes.	Will reduce potential for contaminant spills.
26. Monitor populations, productivity, movements, and general health of key species. Research measures to further minimize adverse effects of development. Implement corrective actions.	Will allow early identification of problems and implementation of corrective measures for caribou, muskoxen, polar bears, snow geese, arctic char, and others.
27. Provide: environmental orientation briefings for workers; program for monitoring development activities; continuation of fish and wildlife population monitoring; follow-up programs to evaluate effects.	Will increase environmental awareness of workers; give managers continuing baseline information to analyze effects of development and improve protective measures; help to ensure effectiveness of mitigation.
28. Develop plans in conjunction with area residents and organizations to properly manage impacts on communities.	Will minimize undesirable sociocultural and socioeconomic impacts, such as chemical dependency, boom-and-bust cycle, and cultural disorientation.
29. Develop and implement an approved rehabilitation plan as part of the appropriate permit stages.	May provide total or partial restoration of habitat values in affected area.

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CHAPTER VII

OIL AND GAS--NATIONAL NEED FOR DOMESTIC SOURCES AND THE 1002 AREA'S POTENTIAL CONTRIBUTION

~ INTRODUCTION ~

Section 1002(h)(5) of the Alaska National Interest Lands Conservation Act of 1980 (ANILCA) requires an evaluation of the relationship of hydrocarbon resources in the 1002 area of the Arctic Refuge to the national need for additional domestic sources of oil and gas. This chapter describes the national need and the potential contribution of oil from the 1002 area. Benefits which would accrue to the Nation include gains in national income, reduced vulnerability to disruptions in the world market, and improvements in the balance of payments and national security. The analysis focuses only on oil because natural gas from the 1002 area may not become economic to produce and transport to market within the 30-year timeframe considered.

The estimates used in this chapter depend on many variables. If the 1002 area were opened and leased in a timely manner, production would not be expected until about the year 2000. Therefore, the 1002 area's contribution to U.S. energy needs has been determined by comparing its production potential with projected energy needs beginning about 15 years from now and extending 30 years out to the year 2030 and possibly beyond.

It is difficult to anticipate either world oil prices beyond the year 2000 or the rate of real growth of the U.S. economy--two important determinants of the future demand for energy. Nevertheless, potential production from the 1002 area can be compared with various forecasts of future U.S. energy demand and supply. This chapter relies mainly on the U.S. Department of Energy's (DOE) long-term reference case projections contained in its 1985 National Energy Policy Plan, but also considers later DOE Energy Information Administration estimates (DOE, 1986a, b; 1987a, b) and several private forecasts (Chevron, 1986; Conoco, 1986; Nehring, 1981). More recent forecasts do not consider the period after the year 2000.

THE 1002 AREA'S POTENTIAL CONTRIBUTION TO U.S. NEEDS

~ The unique geologic features underlying the 1002 area create the potential for discoveries which would make a very substantial contribution to domestic oil reserves. Despite the area's remote location and hostile environment, it is the petroleum exploration target in the onshore U.S. having the greatest potential. Data from outcropping rocks within the area and from nearby wells, combined with seismic information gathered from 1983 to 1985, indicate geologic conditions which are exceptionally favorable for major discoveries. ~

There is a 30-percent chance that an exploratory drilling program on the 1002 area would find hydrocarbons. There is a 63-percent chance that, if hydrocarbons are found, the amount would exceed the minimum economic field size for at least one prospect, resulting in the marginal probability of 19 percent. The 19-percent probability for the 1.5-million-acre 1002 area indicates a very high potential as discussed in Chapter III.

~ The billions of barrels of oil that may exist in the 1002 area could make an important contribution to the national need for domestic sources of oil. Alaska North Slope crude oil, especially that from Prudhoe Bay, now contributes almost 20 percent of domestic production. However, production from Prudhoe Bay has peaked and a decline is expected no later than 1988. The Kuparuk River and other fields are still being developed. They will begin to decline in the 1990's. Oil from the 1002 area could help moderate these declines in supply and substantially reduce the need for increased imports (Riva, 1986, 1987). ~

The oil resources and possible production capability of the larger potential oil fields in the 1002 area are substantial by U.S. standards. Estimates of resources in

Contribution to Domestic Oil Demand and Supply

place range from 4.8 billion barrels of oil (BBO) to more than 29.4 BBO. Recoverable resource estimates range from 0.6 BBO to 9.2 BBO. The potential recoverable resources of some fields in the 1002 area may sizably exceed 1 BBO. Only 13 domestic fields having total reserves greater than 1 BBO have been discovered. Their original reserves, remaining reserves, current production rate, and year of discovery are displayed in table VII-1.

If productive, the 1002 area's fields could be the largest domestic fields discovered since Prudhoe Bay and Kuparuk River in 1968 and 1969. Except for these, no U.S. field with reserves exceeding 1 BBO has been discovered since 1948. The size of the 1002 area's structures and their potential for oil accumulations are geologically the Nation's best onshore targets for the discovery of very large oil fields. If productive, the large fields would join the list of "giant" oil fields which have contributed more than two-thirds of total domestic oil production. The previously discovered giants, except for the two Alaskan fields, are more than 75 percent depleted (table VII-1), and even the Prudhoe Bay field is almost half depleted.

For purposes of assessing the 1002 area's possible contribution, the conditional mean recoverable resource estimate of 3.2 BBO has been used. The estimate for limited leasing is 2.4 BBO. These figures do not consider resources that may occur in undefined but potential stratigraphic traps (see Chapter III).

Table VII-1.--U.S. oil fields having ultimate recovery exceeding 1 billion barrels of oil.

[BBO, billion barrels of oil; MBO/Y, million barrels of oil per year. From Oil and Gas Journal (1986) and Roadifer (1986)]

Field	Year discovered	Original reserves (BBO)	Remaining reserves (BBO)	Current production (MBO/Y)
Prudhoe Bay, AK.....	1968	9.47	5.10	568
East Texas.....	1930	6.00	1.11	48
Wilmington, CA.....	1932	2.55	.36	41
Midway-Sunset, CA.	1894	2.16	.45	54
Kern River, CA.....	1899	1.99	.92	51
Yates, TX.....	1926	1.95	.90	45
Wasson, TX.....	1936	1.68	.57	33
Kuparuk River, AK...	1969	1.59	1.30	79
Elk Hills, CA.....	1911	1.47	.70	47
Panhandle, TX.....	1921	1.46	.07	11
Kelly-Snyder, TX.....	1948	1.35	.15	19
Huntington Beach, CA.....	1920	1.12	.07	8
Slaughter, TX.....	1936	1.03	.06	24

The 1002 area's potential contribution to the national need for domestic oil production is assessed in light of supply and demand conditions. Oil consumption in the United States has exceeded domestic production for more than 20 years. Using the daily production estimates for the 1002 area, table VII-2 compares the area's potential contribution with the Department of Energy's reference case projections for domestic oil supply and demand (DOE, 1985) to illustrate the magnitude of the contribution 1002 area oil production could make in the face of increasing demand and steadily declining domestic production.

The United States has stabilized its oil production capability and temporarily moderated the decline in domestic reserves since 1974. This is largely due to successful exploration and intensive exploitation of known fields, including the use of improved and enhanced oil recovery (EOR) technology, and to the 1.5 million barrels per day produced at Alaska's Prudhoe Bay.

~ United States crude production (excluding natural gas liquids) peaked at 9.64 million barrels of oil per day (MBO/D) in 1970 and has remained relatively constant over the last decade, amounting to 8.7 MBO/D in 1986. In February 1986, the Energy Information Administration (EIA) of the Department of Energy (DOE, 1986b) predicted that domestic crude production would decrease by about 3 percent per year beginning in 1987, declining to about 8.05 MBO/D in 1990 and to 6.53 MBO/D by 1995. In February 1987, however, the EIA's base case estimate (DOE, 1987a) was only 6.0 MBO/D for 1995 and 5.4 MBO/D for the year 2000. Both estimates represent a substantial reduction from previous DOE forecasts, including the reference case in the National Energy Policy Plan (DOE, 1985). ~

~ In June 1986, the Chevron Corporation predicted that production would decrease to 8.8 MBO/D in 1986 and steadily decline to 6.2 MBO/D by the year 2000 (Chevron, 1986). In November 1986, J. P. Riva, of the Science Policy Research Division of the Library of Congress, predicted that production will decrease to 6.9 MBO/D in 2000 if the low drilling activity of 1986 continues. Other recent estimates suggest production levels as low as 4.0 MBO/D by the year 2000. The lower forecasts are largely the result of reduced oil and gas prices, price uncertainty, consequent reduced drilling levels and discovery rates, higher annual production declines in known fields, and decreased emphasis on production stimulation projects (Spaulding, 1986; Doscher and Kostura, 1986; Kuuskraa, 1986; Ray and others, 1986). ~

Crude oil reserves decreased more than 27 percent, about 11 BBO from 1970 to 1985 and declined annually during 14 of these 15 years despite extensive exploration and active field exploitation programs.

Table VII-2.--The 1002 area's potential contribution to U.S. oil demand, production, and imports.

[In thousands of barrels per day. U.S. demand, production, and import data from U.S. Department of Energy, 1985, table 3-10]

Year.....	2000	2005	2010
U.S. OIL DEMAND ¹	16,400	16,000	15,900
1002 AREA OIL PRODUCTION:			
Full leasing.....	147	659	404
Percent of U.S. total demand .....	.9	4.0	2.5
Limited leasing.....	105	473	300
Percent of U.S. total demand.....	.6	2.9	1.8
U.S. OIL PRODUCTION ²	9,000	8,400	7,600
1002 AREA OIL PRODUCTION:			
Full leasing.....	147	659	404
Percent of U.S. total production	1.6	7.9	5.3
Limited leasing.....	105	473	300
Percent of U.S. total production	1.2	5.6	4.0
U.S. OIL IMPORTS (net)	7,400	7,600	8,300
1002 AREA OIL PRODUCTION:			
Full leasing.....	147	659	404
Percent of U.S. total imports.....	2.0	8.7	4.9
Limited leasing.....	105	473	300
Percent of U.S. total imports.....	1.4	6.2	3.6

¹Excludes refinery gains.

²Includes natural gas liquids, enhanced oil recovery, and shale oil. Figures for 1002 area production not included in DOE data.

Riva (Riva, 1984; Riva and others, 1985; Gall, 1986), predicts that shrinking American oil reserves will plunge by 1990 to their lowest levels since shortly after World War II. On the basis of current low drilling rates, Riva (1986, 1987) predicts a decline from the 1985 reserve figure of 28.4 BBO to 25.1 BBO in 1990, to 23.0 BBO in 1995, and to 21.7 BBO in 2000. The most significant declines in reserves will occur in the older, traditional oil-producing areas of the western United States, Texas, the Gulf Coast, and the Midcontinent. In the frontier regions of Alaska and offshore California, prospects are better for substantial reserve additions.

~ The data previously summarized demonstrate that the trend of declining domestic oil production and reserves is accelerating. Exploration and development well drilling have decreased to less than half of 1985 levels and reserves are not being adequately replaced. This situation has very serious long-term consequences. ~

If current production and reserves in known fields are assumed (the reserves/production ratio), theoretically the Nation's oil reserves would be exhausted in about 9 years. But because oil-field production conventionally declines about 10 percent per year compounded, in practice it will take about 30 years to exhaust known reserves.

Production capability and reserves can be increased by (1) exploring for new fields; (2) extending or finding new reservoirs in known fields; (3) producing more of the total oil-in-place by EOR methods, in-fill drilling, well stimulation, etc.; and (4) developing improved production technology. Use of each technique depends on projected prices of oil and gas, economics, and relative costs of the technique.

From 1977 through 1985, a period of high oil prices and the greatest boom in domestic exploration history, an average of 930 million barrels of new reserves were discovered each year (MBO/Y). Revisions and adjustments added an average of 1483 MBO/Y. Consumption during the same period averaged almost 3000 MBO/Y. Reserves therefore decreased by an average of 565 MBO/Y. Approximately 7 percent of the increase resulted from discovery of new fields, 31 percent from the discovery of extensions and new zones in known fields, and 62 percent from EOR, other increased recovery methods, and statistical revisions. Oil is being consumed faster than it is being discovered, and the Nation is reducing its oil inventory.

The historical quantities of petroleum discovered per foot of exploratory drilling dramatically demonstrate the increasing difficulty in finding large oil and gas fields (table VII-3). The downward trend has not reversed since 1979.

Table VII-3.--Historical recoverable U.S. oil and natural gas finding rates.

[MCF, thousand cubic feet.
Modified from U.S. Geological Survey]

Period during which footage was drilled	Increment feet of exploratory drilling (billions)	Finding rate per foot of exploration drilling	
		Oil (barrels)	Gas (MCF)
1859-1949	0.0-0.5	236	916
1949-1958	0.5-1.0	51	347
1958-1967	1.0-1.5	21	252
1967-1977	1.5-2.0	20	186
1977-1979	2.0-2.1	9	134

Fields having recoverable reserves exceeding 100 million barrels of oil (MBO) are frequently described as national class giants. Giant fields having reserves exceeding 500 MBO are supergiants or world class giants. Giants and supergiants are few in number, but contribute the bulk of the world's oil production; fewer than 300 supergiant oil fields (out of 30,000 oil fields worldwide) contain more than 80 percent of the world's known oil reserves. More than 40 supergiants have been discovered in the United States, almost all prior to 1939. Significantly, only five have been discovered since 1951: McArthur River (1965), Prudhoe Bay (1968), and Kuparuk River (1969), all in Alaska; Jay in Florida (1970); and East Anschutz Ranch in the Overthrust Belt in Wyoming (1981). Only one of these was discovered from 1977 to 1985. Point Arguello in the Outer Continental Shelf (OCS) off California may be added to this list once the reserves are fully defined.

Discovery patterns for giant oil fields are only slightly more favorable. About two-thirds of the 270 giants were found before 1940, 94 since, and the number of such discoveries decreases in each successive decade.

Almost all the onshore basins in the United States that hold the greatest potential for very large discoveries, except for the 1002 area, have already been explored. Although some very attractive offshore areas are yet to be explored, the 1002 area is particularly promising because it contains extensions of other producing trends, and wells on adjacent properties show highly favorable evidence of petroleum deposits. These evidences, combined with the structural traps mapped or inferred for the area, indicate that the 1002 area is currently the unexplored area in the United States with the greatest potential to contain giant and supergiant fields (Riva, 1987).

Not only might discovery of supergiant fields significantly contribute to domestic reserves and production, it could do so at a relatively lower average cost per barrel because of economies of scale. The combination of high production and low average costs makes the total net economic value much higher for large fields. Moreover, because average costs are lower, larger fields can be produced more economically and can contribute to the economy even when world oil prices are lower.

Contribution to National Objectives

The potential contribution from 1002 area production goes well beyond that of simply providing a percentage of U.S. domestic oil needs that might otherwise have to be obtained from foreign sources of supply. Production of oil from the 1002 area can help achieve this Nation's national economic and security objectives as well.

FOSTERING ADEQUATE ENERGY SUPPLIES AT REASONABLE COSTS

DOE's 1985 National Energy Policy Plan has as its general goal fostering adequate energy supplies at reasonable costs. Adequate supply requires "a flexible energy system that avoids undue dependence on any single source of supply, foreign or domestic, and thereby contributes to national security [and] implies freedom of choice about the mix and measure of energy needs to meet our industrial, commercial, and personal requirements." The National Energy Policy Plan also recognizes that leasing Federal lands is important in the Nation's effort to ensure long-term energy supplies.

REDUCING DEPENDENCE ON IMPORTED OIL

~ Since 1970 this Nation has depended heavily on foreign petroleum supplies. The prospect is for continued U.S. dependence. Imports in 1986 averaged 6.1 MBO/D, to supply 37 percent of domestic oil needs. During 1986, net oil imports rose 23 percent; oil demand increased 2.5 percent despite a sluggish economy; oil and gas drilling activity fell 50 percent; and direct industry employment dropped more than 26 percent. The latest forecasts show that U.S. dependence on foreign oil is expected to increase significantly by and beyond the end of the century. The National Petroleum Council (1987, table 4) estimated that in the year 2000 the United States will import 52 percent of its oil demand if the price of oil increases to \$36 per barrel and will import 68 percent of its oil demand if the price increases to only \$21 per barrel. Table VII-2 compares the percent of the 1002 area contribution with U.S. oil imports, based on the estimates in the DOE 1985 National Energy Policy Plan. ~

The Nation's oil imports come from two general sources: members of the Organization of Petroleum Exporting Countries (OPEC), such as Saudi Arabia, Venezuela, and Indonesia, and non-OPEC nations, such as Mexico, Canada, and the United Kingdom.

Because of decreasing production in the United States and other non-OPEC nations, this Nation will likely become significantly more dependent on imports from the oil-rich Persian Gulf OPEC nations no later than the mid-1990's. If so, oil prices will increase as supply competition decreases and the Persian Gulf OPEC nations regain market leverage and control of the international oil market.

As imports have increased, the United States has again become vulnerable to the actions of oil-exporting countries. The cost of imported oil to the economy is not only the price paid for the oil but also the potential economic losses caused by a disruption in supply, should one occur. Because domestic production substitutes for oil imports, the Nation benefits both from the savings that result when the costs of producing additional domestic oil are less than the world price, and from a reduction in vulnerability to disruptions of supply. The contribution of the 1002 area's oil resources should be gauged as a displacement of potentially costly and insecure imported oil by less costly, more secure production from domestic fields. The costs of a price change or a supply disruption will be less to the extent that the economy relies more on less expensive domestic supplies than on imported oil. U.S. oil reserve and production trends suggest a shift toward greater vulnerability, possibly exacerbated by the declines of exploration and production in 1985-86. Thus, the 1002 area's oil may be able to significantly reduce the economy's vulnerability to world oil market changes.

ENHANCING NATIONAL SECURITY

Continued dependence on imports for a substantial part of U.S. oil consumption creates many national security concerns. The potential for a supply disruption limits the flexibility of U.S. foreign/national security policy, including the ability to respond to threats. The United States could also potentially be drawn into dangerous political and military situations involving exporting nations. Dependence on oil imports entails dependence on extended supply lines (tanker routes), which are targets for attack; this adds to the defense burden. Key weapons systems in the Nation's arsenal, and under development, use hydrocarbon fuel. Clearly the most secure sources of supply for such fuel are domestic sources.

Secure oil supply lines can have a direct bearing on the achievement of national economic goals that depend on uninterrupted economic activity. Interruption of these supply lines, on the other hand, disrupts the production and consumption of goods and reduces economic activity. This occurred, for example, in the aftermath of the OPEC oil embargo in 1973 when a recession resulted.

DOE's recently issued report (1987c) entitled "Energy security" underscores the economic and national security consequences of relying on imports for a substantial part of our oil needs.

ACHIEVING A MORE FAVORABLE BALANCE OF INTERNATIONAL TRADE

~ The deficit in the U.S. international trade balance has increased significantly in the last decade. For 1985, oil imports represented the single largest item in U.S. international trade accounts. In 1986, the merchandise trade deficit totaled \$170 billion (U.S. Department of Commerce, 1987). In that same year, the gross cost of importing crude oil and refined petroleum products amounted to \$38 billion, or 22 percent of the deficit. If oil imports increase as currently projected, achieving a favorable trade balance will be even more difficult. This problem becomes more severe as the price of imported oil increases. The deficit trade balance has meant that more U.S. dollars are spent on foreign goods, leaving fewer dollars available to U.S. consumers and businesses for U.S. goods and services. Production from the 1002 area would reduce not only the need for imported oil but also the amount of foreign exchange required to pay for imports, resulting in a more favorable trade balance. Using the mean estimate of the anticipated production, oil from the 1002 area could result in U.S. dollar savings spent on imports of \$1.8 billion in the year 2000, \$8.3 billion in 2005, and \$5.4 billion in 2010. ~

PROVIDING ECONOMIC BENEFITS TO THE NATION

~ The importance of oil in the economy is widely recognized. In 1986, 37 percent of the energy used in the United States came from oil, of which approximately 10 MBO/D was produced domestically (crude and petroleum products) and 6.1 MBO/D was imported (DOE, 1987a). ~

If oil can be produced from the 1002 area at a cost lower than its sale price, a net increase in national income will result and a net economic benefit will be realized. The "net national economic benefit" (NNEB) is the expected net value of oil production, or the difference between revenues from sale of oil and the costs of exploration, development, production, and transportation. The NNEB includes economic benefits expected to accrue as bonuses, royalties, rental fees, taxes, and after-tax business profits. The NNEB expected from the mean potential production of 3.2 BBO from the 1002 area under full leasing is 79.4 billion undiscounted 1984 dollars, and 14.6 billion discounted (10 percent real) dollars. Assuming production of 9.2 BBO and an oil price of \$40 per barrel (a more optimistic economic assumption), the undiscounted NNEB would exceed \$325 billion (1984 dollars). Potential oil production under limited leasing would contribute \$54.0 billion undiscounted, and \$9.4 billion discounted. (The discounted value was derived by using a discounted cash flow simulation model, in which annual revenues and annual costs for projected years of production are discounted to the present.)

PROVIDING FEDERAL, STATE, AND
LOCAL REVENUES

Production from leases in the 1002 area could generate revenues to the public as lease bonus payments and rentals, royalties, Federal corporate income taxes, severance tax payments to the State of Alaska, and State corporate income taxes. The revenues expected from providing this return to the public are shown in table VII-4 for the full leasing and limited leasing alternatives. Federal revenues consist of bonuses, royalties, lease rental payments, and corporate income taxes. State and local revenues include property, severance, conservation, and corporate income taxes. Transfer payments from the Federal Government are not included, and the figures do not include Federal revenue sharing.



**THE 1002 AREA'S OIL POTENTIAL
COMPARED TO U.S. PROVED
OIL RESERVES**

~ Table VII-5 shows, for 1986 and 2000, (1) U.S. proved crude oil reserves, for 1986 and projected to the year 2000, and (2) the 1002 area's estimated recoverable resources, under full leasing and limited leasing. "Proved reserves" are those that have been demonstrated with reasonable certainty to be recoverable from known sources, whereas the 1002 area's economically "recoverable resources" are, by definition, speculative and less precise. Notwithstanding the differences between the categories, the U.S. totals represent a benchmark against which to display the magnitude of the 1002 area's potential incremental addition to U.S. reserves, in terms of both quantity and percentage. ~

Table VII-5.--The 1002 area's conditional, economically recoverable oil resources compared with total U.S. proved crude oil reserves.

[In billions of barrels. Year 1986 data from Department of Energy (1986a, p. 6); year 2000 data from Department of Energy (1987a, p. 7)]

	Year	
	1986	2000
U.S. PROVED RESERVES	28.4	19.5
1002 AREA RECOVERABLE RESOURCES		
Full leasing (mean resource level)	3.2	3.2
Potential addition (percent) to U.S. total	11.3	16.4
Full leasing (5% probability level)	9.2	9.2
Potential addition (percent) to U.S. total	32.4	47.2
Limited leasing (mean resource level)	2.4	2.4
Potential addition (percent) to U.S. total	8.5	12.3

Table VII-4.--Estimated revenues, in billions of dollars, under full leasing and limited leasing.

[Bonuses, royalties, lease rental payments, and corporate income taxes are shown as Federal revenues. Portions of some of the seismically mapped structures lie outside the 1002 area. If these non-Federal subsurface areas are leased by others (for example, the State of Alaska or Native Corporations), portions of bonus, rent, and royalty income shown here as Federal revenue would accrue to those organizations]

	Full leasing	Limited leasing
FEDERAL REVENUES		
Undiscounted 1984 dollars	\$ 38.0	\$ 25.9
Discounted dollars (10% real)...	8.0	5.1
STATE AND LOCAL REVENUES		
Undiscounted 1984 dollars	16.1	11.0
Discounted dollars (10% real)...	3.6	2.4

CONTINUED USE OF THE TRANS-ALASKA
PIPELINE SYSTEM

The Trans-Alaska Pipeline System (TAPS) is in place and has been assumed to be available to transport oil from the 1002 area. Such oil could play an important role in helping to offset the declines in production slated for the Alaska North Slope, thereby reducing the per-barrel transportation costs for oil from existing fields. Transportation of the 1002 area's oil is, therefore, likely to prolong the useful life of TAPS and to permit additional production from North Slope fields which would otherwise be uneconomical.

ANTICIPATED MARKETS FOR THE 1002 AREA'S OIL

Assuming that potential oil production from the 1002 area is similar in quality to current North Slope production, the markets for the 1002 area's oil could be expected to follow similar market patterns. Crude oil markets are already established for production from the Alaskan North Slope (ANS), and these markets could probably be used for oil from the 1002 area. Oil produced from Prudhoe Bay and Kuparuk is transported via TAPS to Valdez and from Valdez by tankers to ports on the West, Gulf, and East coasts. The Trans-Panama Pipeline paralleling the Panama Canal is used extensively to transport crude oil from the Pacific Ocean to the Atlantic. Crude oil is off-loaded on the Pacific side and loaded onto tankers on the Atlantic side for shipment to Gulf of Mexico, East Coast, Puerto Rico, and Virgin Islands ports.

Significant discoveries have been made in California's Outer Continental Shelf areas in the Santa Barbara Channel and Santa Maria Basin, and elsewhere. This potential production could effectively back-out a portion of future ANS production that would otherwise be marketed on the West Coast. However, production from known ANS fields is projected to begin declining in 1987 and fall to approximately 29 percent of 1984 production by the year 2000 (Alaska Department of Revenue, 1985). At the same time, crude oil production from the 1002 area is not projected to be on-line until the late 1990's or after the year 2000. Therefore, the market opportunities for the 1002 area's oil could conceivably be available in roughly the same proportions as current ANS markets.

Because of the statutory ban on export of U.S. oil, the West Coast market is well established as the primary area for ANS crude; this is logical if viewed solely on the basis of transportation cost. Shipments to the West Coast increased to a peak of 0.9 MBO/D in 1980. During 1980-84, an average 52 percent of ANS crude oil was marketed on the West Coast. Alaskan crude oil in excess of West Coast demand is transported to the Panama Canal for shipment to other markets.

CONCLUSION

In summary, the 1002 area has a very significant potential to contribute to the national need for oil. Despite the degree of uncertainty, some chance exists that the 1002 area may contain a field the size of Prudhoe Bay; and an even better chance exists of one or more smaller fields, still supergiants, totaling more than 3 billion barrels. Only exploration can provide the information needed to determine the extent and distribution of the resources and, therefore, the potential benefit to the economy.

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PRODUCTION FACILITY

CHAPTER VIII

SECRETARY'S RECOMMENDATION

INTRODUCTION

The Arctic National Wildlife Refuge in Northeastern Alaska is a 19-million-acre unit of the National Wildlife Refuge System. Section 1002(h) of the Alaska National Interest Lands Conservation Act (ANILCA) of 1980 directed the Secretary of the Interior to:

- o conduct biological and geological studies of the 1.5-million-acre coastal plain portion of the Arctic Refuge (the "1002 area");
- o report the results of those studies to the Congress; and
- o recommend to the Congress whether the 1002 area should be made available for oil and gas exploration and development.

During Congressional deliberations in 1977-80 about management of lands in Alaska, the Congress expressed particular interest in the possibility of significant oil and gas deposits in the 1002 area and in the effect of development of such resources on the area's fish, wildlife, and wilderness resources. The Congress set forth a deliberate process for the Department of the Interior to study, analyze and report on all of these resources and to provide a recommendation on future management of the 1002 area.

DISCUSSION

1002 Area Oil and Gas Resources

The 1002 area is the Nation's best single opportunity to increase significantly domestic oil production over the next 40 years. It is rated by geologists as the most

outstanding petroleum exploration target in the onshore United States. Data from nearby wells in the Prudhoe Bay area and in the Canadian Beaufort Sea and Mackenzie Delta, combined with promising seismic data gathered on the 1002 area, indicate extensions of producing trends and other geologic conditions exceptionally favorable for discovery of one or more supergiant fields (larger than 500 million barrels).

The area could contain potentially recoverable oil resources of more than 9.2 billion barrels, an amount nearly equal to the Prudhoe Bay oil field, which currently provides almost one-fifth of U.S. domestic production. If this estimate proves to be correct, development of the 1002 area resources would add significantly to domestic reserves.

Production from the 1002 area could begin at a time when a decline in production is expected at Prudhoe Bay. Alaska North Slope crude oil production, mostly from Prudhoe Bay, currently averages 1.8 million barrels per day. But, Prudhoe Bay production is expected to peak this year and decline to 680,000 barrels per day in the year 2000, and to 250,000 barrels per day in 2010. Production of the 1002 area's potential resources could substantially offset this significant and certain decline.

The proximity of the 1002 area to Prudhoe Bay and the Trans-Alaska Pipeline System also is an important factor. Prudhoe Bay provides a fully developed staging area to support exploration and development activities in the 1002 area. Technologies employed at Prudhoe Bay are readily applicable for the 1002 area. The Trans-Alaska Pipeline System provides a ready means for bringing 1002 area oil to U.S. markets. In addition, transportation of 1002 area oil likely would prolong the useful life of the pipeline system and permit continued production from North Slope fields which otherwise would be uneconomical.

Based on the mean conditional recoverable oil estimate of 3.2 billion barrels, 1002 area production by the year 2005 could provide 4 percent of total U.S. demand; provide 8 percent of U.S. production (about 660,000 barrels per day); and reduce imports by nearly 9 percent (table below). This production could provide net national economic benefits of \$79.4 billion, including Federal revenues of \$38.0 billion.

Discovery of 9.2 billion barrels of oil could yield production of more than 1.5 million barrels per day. Estimates of net national economic benefits based on 9.2 billion barrels of oil production, and other economic assumptions, are as high as \$325 billion.

The 1002 area's potential contribution to U.S. oil demand, production, and imports.

[In thousands of barrels per day. U.S. demand, production, and import data from U.S. Department of Energy, 1985, table 3-10.]

Year.....	2000	2005	2010
U.S. OIL DEMAND ¹	16,400	16,000	15,900
1002 AREA OIL PRODUCTION			
Full leasing.....	147	659	404
Percent of U.S. total demand .....	.9	4.0	2.5
U.S. OIL PRODUCTION ²	9,000	8,400	7,600
1002 AREA OIL PRODUCTION			
Full leasing.....	147	659	404
Percent of U.S. total production	1.6	7.9	5.3
U.S. OIL IMPORTS (net)	7,400	7,600	8,300
1002 AREA OIL PRODUCTION			
Full leasing.....	147	659	404
Percent of U.S. total imports.....	2.0	8.7	4.9

¹Excludes refinery gains.

²Includes natural gas liquids, enhanced oil recovery, and shale oil. Figures for 1002 area production not included in DOE data.

Oil production from the 1002 area would reduce not only the need for imported oil but also the amount of foreign exchange required to pay for petroleum imports, thereby bringing about a more favorable balance of trade. In 1984, the gross cost of importing crude oil and refined petroleum products was more than \$59 billion, an amount approximately equal to 50 percent of the U.S. trade deficit. The cost of imports in 1986 was \$28 billion as a result of lower oil prices. However, the Department of Energy has predicted that by 1995, oil imports may cost the equivalent of \$80 billion.

Production from the 1002 area also would reduce U.S. vulnerability to disruptions in the world oil market and contribute to our national security, particularly in light of the following trends highlighted in the March 1987 Department of Energy report to the President on Energy Security:

- o U.S. oil reserves and production capacity are declining and are expected to decline further over the next decade. The domestic production rate fell about 800,000 barrels per day (9-10 percent drop) in 1986 and is expected to decline an additional 400,000 barrels per day (drop of 4-5 percent more) in 1987. Clearly, should prices continue to fall, production will drop further.
- o U.S. oil consumption, which has exceeded U.S. production since the 1960's, is expected to increase.
- o U.S. oil imports increased almost 1 million barrels per day, to an average of 5.3 million barrels per day for 1986. Between 1990 and 1995, imports are projected to increase to 50 percent of consumption, reaching 8 million to 10 million barrels per day.
- o Persian Gulf countries are expected to supply 30-45 percent of the world's oil by 1995, at which time all OPEC countries combined are projected to provide 45-60 percent of world oil supplies.
- o Reduced U.S. oil exploration and production will increase U.S. reliance on oil from the unstable Persian Gulf region.

America's growing reliance on imported oil for the rest of the century could have potentially serious implications for our national security.

The economic and political consequences of such trends are adverse to U.S. interests. Because the 1002 area is the best domestic opportunity to help reverse or reduce the decline in U.S. oil reserves and production, the public interest demands that the area be made available for oil and gas exploration and development, conducted in an orderly and sensitive manner to avoid unnecessary adverse effects on the environment.

Environmental Consequences of Development

The 1002 area provides a variety of outstanding arctic habitats which support fish and wildlife species of national and international significance, including muskoxen (reintroduced), snow geese, and the Porcupine caribou herd--the sixth largest caribou herd in North America.

More than 50 separate biological studies conducted in the 1002 area since 1980 have been documented in a series of biological baseline studies. These data have been synthesized in the final report and legislative environmental impact statement (final report/LEIS) and used to provide the best assessment of the potential environmental consequences of oil development in the 1002 area.

Potential impacts were assessed at three stages of oil activity: exploration, development drilling, and production. The impact analyses predicted that exploration and development drilling activities would generate only minor or negligible effects on all wildlife resources on the 1002 area. Therefore, the focus of potential impacts is on production and assumes the discovery of 3.2 billion barrels of producible oil (mean conditional recoverable estimate). The impact analyses concluded that in fact more than 9.2 billion barrels could be produced with no significant additional environmental impacts than would result from production of 3.2 billion barrels.

Production of billions of barrels of oil is expected to directly affect only 12,650 acres or 0.8 percent of the 1002 area. The consequences of this level of production on important species such as brown bears, snow geese, wolves, and moose, as well as the Central Arctic caribou herd, are expected to be negligible, minor, or moderate.

The only potential "major" effects are attendant to oil production and are limited to the Porcupine caribou herd and the reintroduced muskox herd. "Major biological effects," for purposes of the analysis, were defined as: "widespread, long-term change in habitat availability or quality which would likely modify natural abundance or distribution of species. Modification will persist at least as long as modifying influences exist." Therefore, "major" is not synonymous with adverse. Either of two conditions, change in species distribution or population dynamics, would result in a rating of "major."

PORCUPINE AND CENTRAL ARCTIC CARIBOU HERDS

Although comparing the effects of Prudhoe Bay development on the Central Arctic caribou herd with the potential effects of similar activities in the 1002 area on the Porcupine caribou herd must be done with caution, experiences at Prudhoe Bay provide a strong measure of assurance that caribou can coexist successfully with oil development.

Substantial empirical evidence has been gathered over the years regarding the interaction of the Central Arctic herd with the Prudhoe Bay complex. Although that herd has had a considerable portion of its range, including calving areas, occupied by oil-production facilities, the herd has prospered and, in fact, tripled in size since oil activities began in the area in 1968.

The fact that billions of barrels of oil have been produced and transported from Prudhoe Bay while the area's fish and wildlife resources continue to thrive indicates that effective environmental techniques and technologies are available for use in the 1002 area, a short distance to the east.

Biological studies have found that the Porcupine caribou herd calves in different areas each year--throughout the 1002 area, elsewhere in the Arctic Refuge, and in Canada--on an area totaling approximately 8.9 million acres. Moreover, the Porcupine caribou herd is present in the 1002 area for calving, postcalving, and insect-relief activities only 6 to 8 weeks annually, primarily from mid-May to mid-July.

The Porcupine caribou herd has shown some preference for calving on the Arctic Refuge coastal plain, including the upper Jago River area (84,000 acres or 5.4 percent of the 1002 area) where portions of the herd have calved in approximately half of the last 15 years. Thus, a potential "major" consequence would be the displacement of those portions of the herd seeking to calve in the upper Jago River area. This would be the case only if the area were the site of a major producing oil field. It is unlikely, though possible, that such displacement would result in any appreciable decline in herd size.

It is important to note that this issue of displacement is a primary matter of concern regarding the Porcupine caribou herd. Although it is not known whether development, including roads and oil pipelines, could affect the migratory habits of the herd, it already encounters the Dempster Highway in Canada during its annual migrations and crosses the road with no measured adverse effects. Similarly, other caribou herds in Alaska and Canada (i.e., Nelchina, Fortymile, and Central Arctic) routinely cross highway and road systems. Both the Central Arctic and Nelchina herds also routinely cross the Trans-Alaska Pipeline with no adverse effects. This pattern of successful interaction with roads and pipelines during migration is expected for the Porcupine caribou herd.

In addition, the Porcupine caribou herd should not be affected adversely during the short-term period (6 to 10 days) that they use 1002 area habitats for insect relief following calving. The ability of the herd to move to insect-relief areas along the coast is unlikely to be significantly affected by pipeline/road corridors crossing the 1002 area.

Furthermore, the long period of time required to bring commercial fields into production would provide ample opportunity to develop any additional mitigation measures as may be needed to address unexpected impacts.

Biological predictions necessarily are cautious. In the 1972 environmental evaluation for the Trans-Alaska Pipeline System, the following possible effects on the Central Arctic herd were predicted: "The combined barrier effects of the highway and pipeline might very well reduce the number of animals using the winter range east of the highway." As events have demonstrated, however, these concerns subsequently were resolved completely with environmentally sensitive techniques and technologies. Biological predictions in the final report/LEIS for the 1002 area naturally are cautious as well.

MUSKOXEN

Muskoxen disappeared from the 1002 area at the turn of the century. Those that now occupy the area are the result of a successful reintroduction program. The potential effects of oil and gas activities on the area's muskoxen also are unknown, although biologists predict that "major" effects could be: (1) substantial displacement from currently used habitat and (2) a slowing of the herd's growth rate, as distinguished from a diminution in herd size.

Environmental Safeguards and the Leasing Process

The potential effects predicted above have been considered fully throughout the final report/LEIS and in the development of my recommendations. I also have recognized that site-specific measures can be taken to avoid unnecessary adverse effects on the environment from oil production in the 1002 area.

The step-by-step environmental planning, review, and evaluation procedures included in a leasing program provide the best opportunity for the Department of the Interior to make decisions based on the most accurate and advanced information available at each step of the process.

The following steps might be included in such a leasing program, although the exact process would depend upon the leasing program established by the Congress:

- o Compliance with the National Environmental Policy Act (NEPA) for each lease sale. Lease stipulations and mitigation measures are identified at this stage and are in effect for the entire term of the specified lease.
- o Compliance with NEPA for each exploration plan.

- o Compliance by each operator/lessee, or the Department of the Interior, as appropriate with such laws as NEPA, the Clean Air Act, Clean Water Act, Endangered Species Act, National Historic Preservation Act, and ANILCA. The lease also would be governed by Departmental regulations.
- o Compliance with NEPA for each operator/lessee development and production plan.

SECRETARY'S RECOMMENDATION

I recommend that the Congress direct the Secretary of the Interior (Secretary) to conduct an orderly oil and gas leasing program for the entire 1.5-million-acre 1002 area at such pace and in such circumstances as he determines will avoid unnecessary adverse effects on the environment.

- o The Secretary should be given authority to establish requirements for oil and gas operations that allow them to proceed in an economically reasonable manner but avoid unnecessary adverse effects on the 1002 area's wildlife, habitat, and environment.
- o Competitive leasing authority should be granted to the Secretary to delegate as he believes proper, and should be similar to that used to lease the National Petroleum Reserve in Alaska. The Secretary should also have authority to decide such issues as unitization, drainage, diligence, and lease terms and management.
- o The Secretary should be granted authority to suspend or terminate any leases in the 1002 area at any time, in the same manner prescribed by the Outer Continental Shelf Lands Act as amended. If leases are terminated for reasons beyond the control of the operators/lessees, operators/lessees should be compensated in a manner similar to that prescribed by the Outer Continental Shelf Lands Act as amended.
- o The Secretary should have the authority to require lessees to restore the leased tract to protect environmental values to the extent reasonably possible and desirable.
- o The Secretary should be granted authority, which supersedes ANILCA Title XI, to grant rights-of-way and easements across 1002 area lands for oil- and gas-related activities and facilities. This authority must allow the Secretary to require siting and modifications of proposed facilities to avoid unnecessary duplication of roads and pipelines.
- o All geological and geophysical data acquired with respect to the 1002 area should be shared, upon request, with the Secretary who should ensure its confidentiality.

In light of the extensive environmental analysis done to prepare the final report/LEIS, I recommend that it be adopted statutorily as the programmatic EIS for a leasing program for the 1002 area.

Because Section 1002(i) of ANILCA withdrew the 1002 area from operation of the mineral leasing laws, and Section 1003 prohibited "leasing or other development leading to the production of oil and gas" in the area "until authorized by an Act of Congress," specific legislation must be enacted to implement my recommendations.

In recommending that Congress enact legislation to open the 1002 area for oil and gas leasing, I also recommend that Congress enact legislation to open the Kaktovik Inupiat Corporation (KIC)/Arctic Slope Regional Corporation (ASRC) lands within the Arctic Refuge to similar activities.

The ASRC's right to develop and produce any oil and gas which may underlie the KIC/ASRC lands within the Arctic Refuge is, by virtue of the 1983 Chandler Lake Exchange Agreement, expressly contingent upon Congressional authorization of oil and gas leasing or development and production within the 1002 area, or on the KIC/ASRC lands specifically.¹

Selection Of Preferred Alternative (Alternative A)

I have selected Alternative A, Full Leasing, as my preferred alternative for management of the 1002 area, after evaluating carefully the five alternatives in Chapter V of the final report/LEIS, pursuant to the requirements of the National Environmental Policy Act. I believe that Alternative A best meets the Nation's goals and responsibilities.

Before selecting this alternative, I considered the information presented in the final report/LEIS, the draft recommendation of the Assistant Secretary for Fish and Wildlife and Parks, comments and information received during the public-comment period, and consultations with the Government of Canada.

¹KIC selected and received conveyance of surface estate in these lands pursuant to the Alaska Native Claims Settlement Act (ANCSA) and ANILCA. In passing ANILCA, Congress gave ASRC the option of acquiring subsurface estate in these lands if, in the future, it opened the 1002 area to commercial oil and gas development. By entering into the Chandler Lake Agreement pursuant to ANILCA and ANCSA, the Department of the Interior in effect allowed ASRC to accelerate exercising this option in return for conveying to the Federal government valuable ASRC park inholdings the Department would not have obtained otherwise. ASRC also agreed that development and production of oil and gas on the Arctic Refuge lands would be contingent upon a subsequent act of the Congress.

I have considered the 1002 area's unique opportunity to provide potentially enormous quantities of domestic oil, in light of America's increasing dependence on imports. Oil production from the 1002 area could begin at a time when America's largest producing field, Prudhoe Bay, will be diminishing. I also have considered the potential \$79 billion to \$325 billion contribution to the Nation's economy from development of the 1002 area's estimated oil resources, as well as the favorable effects on our balance of trade and national security.

In addition, I evaluated the potential effects of developing these potential hydrocarbon resources on the wilderness, wildlife, and subsistence values of the coastal plain. Many commenters indicated the need and desire to conserve the significant environmental values of the 1002 area. Public comment also overwhelmingly supported opening the area for oil and gas development. My recommendation reflects my firm belief, based on demonstrated success at Prudhoe Bay and elsewhere, that oil and gas activities can be conducted in the 1002 area in a manner consistent with the need and desire to conserve the area's significant environmental values.

Our ability to conduct oil exploration, development, and production in a careful and environmentally sound manner is a factor leading me to designate Alternative A as the environmentally preferred alternative. This conclusion is based on the environmental impacts of substitute sources of energy. The Department of the Interior's analysis of these impacts, described in Chapter VI of the final report/LEIS, concludes that each of the available substitute possibilities involves a large measure of environmental harm. Also, in the event of a future energy crisis, there would be strong pressure to develop rapidly, promising areas like the 1002 area, without regard for environmental factors.

Alternative E--Wilderness Designation

Several commenters supported Alternative E, which calls for designation of the 1002 area as wilderness² pursuant to the 1964 Wilderness Act and ANILCA. I am persuaded that such designation is not necessary to protect the 1002 area environment and is not in the best interest of the Nation.

²The Wilderness Act provides that "there shall be no commercial enterprise and no permanent road within any wilderness area and, except as necessary to meet minimum requirements for the administration of the area * * * there shall be no temporary roads, no use of motor vehicles, motorized equipment, or motorboats, no landing of aircraft, no other form of mechanical transport, and no structure or installation within any such area" 16 U.S.C. 113(c). Congress has recognized some special uses allowable in Alaskan wilderness areas which are described in Chapter V of the final report/LEIS.

A criterion used in determining whether certain lands should be designated wilderness is uniqueness. In Alaska, there are approximately 55 million acres of Federal land set aside by statute as wilderness and another 80 million acres managed as national parks, preserves, wildlife refuges, wild and scenic rivers, and conservation or recreation areas. In addition, there are millions of acres in Alaska which constitute nonstatutory wilderness. Moreover, the 1.5-million-acre 1002 area (about 8 percent of the Arctic Refuge) is bordered to the south and east by more than 8 million acres of designated wilderness. (For reference, 8 million acres is equal to the combined size of the States of Connecticut and Massachusetts; 55 million acres is equal to the combined acreage of the six New England States, Delaware, Maryland, and New Jersey.) To the east of the 1002 area is Canada's 3-million-acre Northern Yukon National Park.

Given the existence of extensive lands set aside for wilderness and other preservation purposes in this area and in Alaska, the 1002 area's value as statutory wilderness is not unique.

On the other hand, the enormous oil potential of the 1002 area, believed to be America's last onshore area with such potential, provides a unique opportunity to contribute to the Nation's energy, economic, and national security. Because environmentally sensitive management techniques and technologies are available and can be employed to protect the important fish and wildlife values of the coastal plain, we need not forgo the opportunity to develop the 1002 area's potential energy resources.

The fish and wildlife species that might be affected by oil and gas activities in the 1002 area are very important but are neither threatened nor endangered. In fact, they are relatively abundant in Alaska and North America. As noted earlier, the Porcupine caribou herd is the sixth largest caribou herd in North America. The muskox reintroduction effort has been so successful that some hunting is now permitted. Once again, the potential effects of oil production on other wildlife values are expected to be moderate to negligible. Constant monitoring of oil activities is likely to ensure that this continues to be the case. Most effects of any development would disappear with time, once activities cease and reclamation requirements are fulfilled.

With regard to subsistence, potential effects of 1002 area oil production fall into two categories: effects on the village of Kaktovik and effects on villages far removed from the 1002 area. In the case of Kaktovik, it is possible that a "major" restriction of subsistence activities could occur. These consequences would not likely result from reduced wildlife resources but rather could result from the physical changes proximate to Kaktovik which could interfere with traditional activities. Moreover, distribution patterns of wildlife resources likely to be affected by oil production would necessitate some alterations in traditional subsistence patterns.

The Department of the Interior is committed to working with the village of Kaktovik, the North Slope Borough, and the State of Alaska to minimize the effects of oil activities on the subsistence activities of Kaktovik residents.

Subsistence effects on villages outside the 1002 area, including those in Canada, are expected to be minimal. Because it is most probable that oil activities will not create adverse population changes in the Porcupine caribou herd, other villages which annually use these caribou resources should not be affected. Migratory patterns of the herd also are likely to be unaffected by oil activities. Accordingly, the herd is expected to adhere to its traditional patterns which make it available annually to these villages.

I recognize the importance of ensuring the continued customary and traditional use of this internationally shared resource. I am committed to efforts that will conserve the Porcupine caribou herd for future generations of people who rely on this resource for nutritional, cultural, and other essential needs. The Porcupine caribou agreement we are pursuing with Canada will enhance international cooperation and coordination on management of the Porcupine caribou herd so that both countries can effectively secure the availability of this resource.

Some proponents of Alternative E have suggested that the 1-in-5 probability of finding economically recoverable oil resources in the 1002 area does not outweigh the potential environmental risks.

First, the chances of finding oil in the 1002 area are rated by geologists to be excellent compared to other frontier regions. Second, biological assessments have concluded that exploratory drilling following leasing would have minor or negligible environmental effects. Finally, if no oil is discovered, effects on the 1002 area environment would be negligible and the area would not likely be an exploration target in the event of future oil-supply disruptions.

Alternative D--No Action

For many of the reasons described above, Alternative D, No Action, is also not the preferable choice.

Authority to lease the 1002 area is needed now in order to determine whether economically recoverable reserves exist and to produce those resources for America's future. Even if exploration resulted in commercial finds today, it could be as long as 10 to 15 years before those resources would be brought into production. If we delay, our inaction would serve to blindfold America to its ability to increase domestic production. It also would send a dangerous signal to the world oil market that America is not willing to help itself avoid increased dependence on the Middle East's substantial concentration of world oil supply.

Alternative C--Further Exploration

Alternative C, which would provide for further exploration before the Congress enacts leasing authority, was rejected for several reasons.

Without authorization for a leasing program, the private sector cannot be expected to invest financial resources in exploring the 1002 area. Incentive for additional exploration can be provided only by expected returns if commercially producible oil is discovered. This incentive exists only when leases can be acquired and subsequently developed.

Lacking proper economic incentives, Alternative C could necessitate a Federal exploration program for the 1002 area. Such an approach has serious disadvantages. A federally funded exploration program would require substantial outlays at a time of severe Federal budget constraint. Moreover, history shows that it is unlikely that the Federal government could conduct an effective and timely exploration program. Government agencies are not geared to make large, high-risk investment decisions. The Federal government has been harshly criticized for its lack of success in managing a federal exploration program for the National Petroleum Reserve in Alaska.

Alternative B--Limited Leasing

Alternative B would limit the amount of the 1002 area available for exploration and development by excluding the upper Jago River area. This alternative would lower the oil resource estimate for the 1002 area by 25 percent and reduce the mean expected net national economic benefits by about 30 percent.

The primary difference in environmental concerns between Alternatives A and B is the unlikely but potential risk to the Porcupine caribou herd from oil production activities in the upper Jago River area.

Such activities are likely to displace portions of the Porcupine caribou herd from that area, but it is probable that such displacement would take place without consequential adverse population effects. The mere presence of such a risk makes no compelling case for forgoing the potential for billions of barrels of oil and the attendant national economic and energy security benefits. In addition, as noted earlier, the long period of time required to bring oil into production provides ample opportunity to develop any additional mitigation measures as may be necessary to address unexpected impacts.

Given the proven record that potential environmental effects of oil production can be avoided substantially, and given America's need for additional domestic energy resources, it is essential that the Congress enact legislation to authorize the Secretary of the Interior to conduct an orderly oil and gas leasing program for the entire 1002 area.

CONSULTATIONS WITH CANADA

In conducting biological studies for the 1002 area related to the Porcupine caribou herd, the U.S. Fish and Wildlife Service worked closely with biologists from the State of Alaska and the Canadian Wildlife Service. The Canadian Wildlife Service and its Yukon Wildlife Branch conducted independent studies of the Porcupine caribou herd during 1978-81 relative to potential oil and gas development in Canada's Yukon and Northwest Territories. Prior to assessing potential environmental consequences of oil and gas development in the 1002 area, the Fish and Wildlife Service conducted a Caribou Impact Analysis Workshop in which Canadian biologists participated at our invitation.

In addition to these technical consultations, representatives of the Fish and Wildlife Service and Canadian Wildlife Service for the past several years have been negotiating a separate Porcupine caribou herd agreement. The final draft agreement, now being reviewed by the Department of the Interior, calls for both countries to take appropriate steps to ensure international cooperation and coordination of actions that might affect the Porcupine caribou herd in order to conserve the species and its habitat. The agreement would establish an advisory board to make recommendations and provide advice to each government to assist in this management effort. Such an agreement will enhance the consultative mechanisms between Canada and the United States on future activities that may be conducted on either side of the border.

When the draft 1002(h) report was made available to the Congress and public for review in November 1986, the Department of the Interior's Assistant Secretary for Fish and Wildlife and Parks also invited the Government of Canada to comment on the draft. To date, three consultation sessions have been held, two in Ottawa and one in Washington, D.C. These sessions provided both countries the opportunity to discuss the biological and geological data upon which this final report/LEIS is based and to address the assessment of impacts on the Porcupine caribou herd and other wildlife resources by possible development activities. Consultations will continue upon request by either country, and the Department of the Interior looks forward to future opportunities to discuss with Canada resource issues of mutual concern.

CONCLUSION

The Secretary of the Interior should seek both to protect the Nation's wildlife resources and to enhance America's ability to meet its energy needs with domestic energy resources on Federal lands. For the Arctic National Wildlife Refuge coastal plain, these goals affect not only the State of Alaska but also all 240 million American citizens to whom the 1002 area belongs.

This Nation has proven that it need not choose between an improving environment on the one hand, and exploration and development of the energy resources required for growth and survival on the other. We can have both. It is my firm belief that an orderly oil and gas leasing program for the entire 1002 area can be conducted in concert with America's environmental goals.



GEESE

~ SUMMARY OF CONSULTATION AND
PUBLIC COMMENTS ~

BACKGROUND

During preparation of the preliminary draft report and detailed LEIS for departmental review, Trustees for Alaska and other environmental groups took legal action against the Department and the Fish and Wildlife Service (Trustees for Alaska, et al., v. Donald P. Hodel et al., February 25, 1986). Plaintiffs contended that the Department failed to fully comply with the provisions of the National Environmental Policy Act (NEPA) and must provide an opportunity for public participation in preparation of the report/LEIS in advance of its submittal to the Congress. They took exception to the Department's plans to circulate the report/LEIS for public comment concurrently with submittal of the report to the Congress, and to forward comments and Departmental responses subsequently to the Congress. By court order, the Department was directed to prepare both a draft and a final report/LEIS, and to permit public review and comment on the draft LEIS. The court further directed that public meetings on the draft be held in Alaska and elsewhere, and that the Department's responses to comments be published locally before or at the time the final report/LEIS is submitted to the Congress. The Ninth Circuit Court of Appeals affirmed the district court order.

On November 24, 1986, the draft report/LEIS was made available for public review and comment. Originally scheduled to close January 23, 1987, the comment period was extended to February 6, 1987, at the request of the Governor of Alaska and others. Public meetings were held January 5, 1987, in Anchorage, Alaska; January 6, in Kaktovik, Alaska; and January 9 in Washington, D.C.

More than 200 individuals participated in the public meetings and submitted oral or written statements, or both. Transcripts of these three hearings are available for public review in the following locations:

U.S. Fish and Wildlife Service
Division of Refuges
Room 2343, Main Interior Building
18th and C Streets, NW.
Washington, D.C. 20240

and

U.S. Fish and Wildlife Service
Alaska Regional Office - Planning
1011 East Tudor Road
Anchorage, Alaska 99503

**Statistics for Responses to Proposed
Recommendation in the Draft LEIS.**

State/Country	Yes	No	Total
Alabama	18	2	20
Alaska	1,311	407	1,718
Arizona	90	28	118
Arkansas	21	1	22
California	564	839	1,403
Colorado	138	43	181
Connecticut	98	46	144
Delaware	27	6	33
District of Columbia	16	5	21
Florida	258	124	382
Georgia	42	33	75
Hawaii	4	4	8
Idaho	13	7	20
Illinois	230	130	360
Indiana	86	140	226
Iowa	27	21	48
Kansas	134	7	141
Kentucky	35	4	39
Louisiana	181	21	202
Maine	13	9	22
Maryland	53	50	103
Massachusetts	53	118	171
Michigan	62	105	167
Minnesota	55	57	112
Mississippi	26	4	30
Missouri	94	46	140
Montana	84	33	117
Nebraska	55	7	62
Nevada	21	11	32
New Hampshire	10	14	24
New Jersey	156	67	223
New Mexico	66	19	85
New York	169	289	458
North Carolina	41	28	69
North Dakota	42	1	43
Ohio	142	50	192
Oklahoma	609	17	626
Oregon	34	44	78
Pennsylvania	547	128	675
Rhode Island	13	12	25
South Carolina	15	48	63
South Dakota	18	2	20
Tennessee	35	19	54
Texas	1,192	64	1,256
Utah	25	3	28
Vermont	4	34	38
Virginia	90	41	131
Washington	128	422	550
West Virginia	208	7	215
Wisconsin	58	74	132
Wyoming	51	7	58
Canada	<u>1</u>	<u>5</u>	<u>6</u>
Total	7,491	3,707	11,198

Copies of the draft report/LEIS were sent to all Federal, State, and local agencies with jurisdiction by law or special expertise, to the Government of Canada and the Yukon and Northwest Territories, to conservation organizations, oil and gas industry, selected libraries, the media, and others who requested copies. Distribution of the final report is described at the end of this section.

RESULTS

During the comment period, 11,361 letters were received. The vast majority of these letters (11,244) were generally a statement either that the area should be opened to further oil and gas activity or that the area should be designated as wilderness. Of these letters, 7,491 favored leasing and 3,707 favored wilderness designation. Forty-six letters expressed no definite opinion. Statistical summaries by State and position are presented in the table (preceding page).

Many of the letters were the results of various mail-in campaigns inspired by industry and conservation organizations. A variety of these comment letters have been reproduced in the Appendix (volume 2). They are representative samples of the pro and con statements, petitions, individually thought-out responses, and mail-in campaigns. All these comment letters are available for public review in the Washington Office of the U.S. Fish and Wildlife Service, address provided above. Written comments provided at the three public hearings are included in that public record, unless they contained substantive issues concerning the content of the report (see discussion below). Included in the 11,244 letters were responses from 821 organizations, industries, associations, etc.; and 10,423 private individuals.

Substantive comments on the contents of the report itself were received from the remaining 117 respondents and are published in their entirety in the Appendix. To facilitate analyses, the comments were broken down into the following categories:

- Federal governments and agencies (9 letters)
- State and local governments (10 letters)
- Industry (16 letters)
- Organizations (42 letters)
- Private individuals (40 letters)

If written testimony filed at the public meetings contained substantive comments, such testimony is also addressed in this section, and has been reproduced in the Appendix.

Each of the 117 letters was analyzed and substantive issues or additional information were delineated, and considered both individually and collectively. Oral testimonies presented at the hearings and documented in the transcripts have also been reviewed, and the concerns and issues raised there have been addressed in the report and responses as appropriate.

Over 1,650 individual comments were contained in the 117 letters. These substantive comments have been summarized by major topic or issue, and detailed responses are included below. The final report/LEIS has been modified as appropriate based on comments received. Throughout the report, the symbol ~ indicates: (1) passages that have been significantly modified from the draft LEIS; or (2) new material that has been added.

RESPONSES TO COMMENTS

Environmental Issues (Chapters II and VI)

CARIBOU

The anticipated effects on the Porcupine caribou herd (PCH) and, to a lesser extent, the Central Arctic Herd (CAH), generated more public comment than any other aspect of possible oil and gas activity in the 1002 area. This topic has been extensively revised in both Chapters II and VI based on these comments. Additional information has become available since the draft LEIS/report was prepared, and has been reflected in the analysis in the final. Although the comments were numerous, most were repetitive of a few major concerns, which have been summarized and responded to below.

PCH CORE CALVING AREA

On the basis of respondents' comments, it was obvious that the draft report's designation of a "core" calving area was being misinterpreted as a very specific area absolutely essential to the viability of the PCH.

The term "core" was used to identify areas repeatedly used by large numbers of calving caribou (density of at least 50 animals/square mile as described in the draft LEIS/report). Areas were identified as core calving areas in the draft report where surveys indicated concentrated use in at least 5 of the 14 years for which detailed observations have been made. Information received since the draft report was prepared added another year of calving distribution information to this data base.

Data leave little doubt that there are important birthing areas in spite of some broad variations from year to year (fig. II-5 and pl. 2A). Based on further review and consultations with Canada, it is questionable to conclude that the repeatedly used concentrated calving habitat on the Jago River is "unique and irreplaceable on a national basis or in the ecoregion" (Resource Category 1 designation, FWS mitigation policy), or that displacement would be sufficient to threaten the viability of the PCH. Accordingly, designations of a "core" calving area and Resource Category 1 habitat have been deleted from the final report.

We believe that the documentation of PCH calving within the 1002 area and additions to the discussion of the importance of calving in the caribou life cycle adequately address this issue without using strictly subjective measures for impact analysis.

PCH DISPLACEMENT VS. DECREASE IN POPULATION

Several commenters, including those from Canada, were concerned with what seemed to be a 20 to 40 percent projected population decline for the PCH.

The draft report did not predict a 20 to 40 percent decrease in herd size. The percentage was related to distribution changes, but through an editing error in punctuation, the relationship was obscured. However, this prompted the FWS to conduct further analysis and consideration of concentrated calving patterns which has suggested that quantifying a percentage in change of distribution (that is, percent displaced) would be highly speculative. Therefore, such information has been dropped from the text and clarification provided.

AREA OF DISPLACEMENT

One of the more controversial aspects of the environmental analysis for caribou concerned the assumption that caribou would be displaced 3 km out from either side of development, roads, and associated facilities. The draft LEIS described this area as 2 miles (3 km = 1.86 mi) in conformance with use of English units throughout the report. However, all computer analyses of areas which would be affected on the basis of this displacement used 3 km, as reported in the literature (Dau and Cameron, 1986). Because several commenters expressed confusion over the use of 2 miles, the references and discussion in the final LEIS were changed to 3 km to be consistent with the literature.

The text has been modified to correct the implication that there would be a complete loss of habitat values within this 3-km area. There would be a reduction in habitat values in varying degrees throughout the area within 3 km of development, with significant declines most likely 2 km outward from the development facilities. This is based on the Dau and Cameron study which showed such decreases in use from disturbance levels much lower than are likely to occur under the full and limited leasing scenarios. Further information on the Dau and Cameron (1986) study, which was the basis for the 3-km displacement zone, has been provided.

Because of concerns over use of the Dau and Cameron data, the Alaska Department of Fish and Game (ADF&G) met with representatives of the oil industry February 13, 1987, to clarify data collection and analysis procedures. Additional statistical tests were applied to the data; reanalyses confirmed displacement, and consistently supported the results and conclusions of the original Dau

and Cameron report. Oil industry representatives agreed that displacement of caribou from the Milne Point road had occurred even though the Dau and Cameron study was conducted during periods of very low traffic activity. On February 27, 1987, the ADF&G and oil industry representatives presented the clarified data to FWS. The analysis in Chapter VI has been revised to reflect this clarification.

MAPPING AREAS OF PCH CONCENTRATION

A few commenters suggested that the maps and calculations concerning areas of concentration and densities of PCH on their calving grounds did not reflect all available information.

Further information on the caribou densities in observed concentration areas has been provided in the report, including the assumptions used to calculate densities of between 46 and 128 caribou/square mile for each concentration area in 1983 and in 1984. Limited measurements made in 1972 near the Jago River showed densities ranging from 8.2 to 375 caribou/square mile. Because the difference between high density concentrated and low-density scattered calving areas is readily apparent, use of the term "concentrated" by previous observers was assumed to reflect densities of similar magnitude.

Since preparation of the draft report, additional information has been made available to the FWS concerning the distribution of PCH calving. This has permitted refinement in mapping and analyzing calving distributions in Alaska and Canada for 1972-81. Some of these refinements have been made possible through the recent preparation of large-scale maps of calving distribution for the years 1978-81 by the Yukon Wildlife Branch. The Yukon Wildlife Branch maps were based on field notes and maps prepared by the original investigator, and are more accurate than the small-scale maps used by the FWS for preparation of the draft report.

For the years 1972-77, large-scale maps prepared by the original investigators were destroyed in a fire, leaving only small-scale maps for use in preparing the draft report. Working with the FWS, D. G. Roseneau, one of the field investigators working on the Arctic Refuge during the Arctic Gas studies, identified and corrected inaccuracies in the maps in the draft report for calving distribution for 1972-77. Earlier inaccuracies resulted from the FWS interpretation and transformation of small-scale maps to a larger scale. The refinements are based upon Roseneau's field notes and recollection.

The refined concentration areas are depicted in figure II-5 and plate 2A of the final LEIS and included in all quantifications of calving areas.

CARIBOU INSECT RELIEF

Numerous comments addressed the issue of insect relief, the areas and conditions sought by caribou for relief, and the significance of insect avoidance behavior in relation to the effects of possible development. The report has been revised to clarify or expand the discussion of insect relief phenomenon.

Insect relief is generally meant to include avoidance of both mosquitoes and oestrid flies. On the 1002 area oestrid flies are not believed to be the nuisance to the PCH that they are to the CAH. The majority of the PCH have generally left the area by peak oestrid fly emergence, although some flies may be present in early July. Generally, PCH movements to insect-relief habitats appear to be in response to mosquitoes.

Evidence suggests that insects play a very strong role in influencing caribou behavior, activity and movements. The text in Chapter VI has been expanded to reflect this fact.

Some commenters suggested that use of coastal areas for insect relief was inconsistent. The FWS disagrees. During the last 15 years, coastal insect relief was used on the average of every other year by extremely large numbers of PCH caribou (Garner and Reynolds, 1982, 1983, 1984, and 1985).

These and other commenters pointed out that the main oil pipeline should present no obstacle to PCH in their movements to coastal relief habitats, based on CAH crossing success in the Prudhoe Bay area. Even large groups (a few thousand) in the CAH that successfully negotiate pipelines, roads, and other developments are much smaller than postcalving aggregations of the PCH (up to 80,000). If these large groups of PCH caribou react negatively to disturbance as some observations suggest, there could be large-scale exclusion of caribou from coastal areas.

POLAR BEARS

There were numerous comments that loss of the one or two bears known to den on the 1002 area each year did not indicate a moderate impact to the Beaufort Sea polar bear population. This section in Chapter VI has been clarified. Figures presented in the text are for known dens, based on radio-telemetry studies of only a fraction of the total denning bears within the Beaufort Sea population. Only 5 to 20 percent of the approximately 150 females which den each year are radio tagged. Thus, there are probably numerous other bears denning on the 1002 area which could also be adversely affected by development. These numbers are even more important when considering that 10 of the 12 land dens found during the 1981-86 radio telemetry studies were located on the Arctic Refuge. Seven of those dens were within the 1002 area.

CARRYING CAPACITY

A few commenters noted that carrying capacities of the Arctic Refuge coastal plain are not presented in the Baseline Study, as was required by Section 1002(c)(b), or in the draft LEIS/report. Despite the extensive baseline studies that have been conducted, current knowledge is inadequate to address the concept of carrying capacity on the 1002 area for the various fish and wildlife species that seasonally occupy the coastal plain. This fact is noted in the final Baseline Report and throughout Chapters II and VI of the report.

The use of primary productivity (annual growth of vegetation) by the various secondary consumers (herbivores) is not well documented for the Arctic. Similarly, the role of interspecific and intraspecific competition of herbivores in altering the biotic carrying capacity of the coastal plain of the Arctic Refuge has not been quantified. Also, nonhabitat factors (predation, disease, behavior, weather, etc.) that can modify the carrying capacity of the area are not well understood. Carrying capacity of tertiary consumers (predators and omnivores) is dependent upon the distribution and abundance of their prey species. Therefore, carrying capacity of tertiary consumers can only be established after the carrying capacity of their prey has been established. Until data are available to address these information gaps, valid estimates of carrying capacity of the 1002 area are not possible.

TRANSBOUNDARY CONSEQUENCES

The Government of the Yukon felt that there was inadequate treatment of the transboundary consequences of those direct impacts on wildlife that use the coastal plain and Canadian habitats or are important constituents of a larger regional population. This point is well taken, and Chapters II and VI have been expanded to address the effects on transboundary wildlife species: caribou, waterfowl, and marine mammals.

BASELINE REPORT

A few organizations commented that the final baseline report was unavailable at the time the draft report/LEIS was made public. This was true due to printing difficulties; however, the final baseline was available by January 1987, allowing sufficient time for review. Despite its length, that report provides updates and summaries of previous annual baseline reports published and publicly available since April 1982. The reports were prepared by those who also contributed to the preparation of the 1002 report, so, inevitably, the report reflects information in all the baseline studies. In fact, these baseline studies have provided the basis for the biological and socioeconomic portions of Chapters II and VI, as they were intended to do.

The final report/LEIS also has been updated to include the 1985 baseline information. The 1985 baseline is in press, and the entire baseline series will be available for the Congress and the public when the Congress begins consideration of the report and the Secretary's recommendation.

REGULATORY PROCESSES

The Environmental Protection Agency concluded that the discussion of the regulatory process and its relationships to the alternatives needed to be expanded. The focus of their comments was on:

- o The existing regulatory process including examples of how existing regulations are applied on the North Slope for oil and gas development.
- o The Section 404 program, in particular the success of Abbreviated Permit Process, designed to expedite oil and gas development on the North Slope.
- o The potential applicability and use of the advanced identification process for advanced planning.

Department of the Army Section 10/404 permits are the primary basis for current FWS involvement in existing North Slope oil and gas developments. The FWS does not believe that the effectiveness of this process has been impaired by development of the Abbreviated Permit Process. Also, the FWS has supported the advanced identification process, and considers it to be useful for making concerns known early in the decisionmaking process.

MITIGATION

Comments relevant to mitigation, ranging from criticism that ameliorative measures were too stringent to complaints that they were totally inadequate, revolved generally around the following issues:

1. Some reviewers criticized the FWS mitigation policy and its habitat-based evaluation system. They contended that animal populations in the Arctic have not been shown to be regulated by habitat availability. They further contended that the most biologically effective approach to assessing and mitigating effects is to determine how oil development will adversely affect given populations and then apply mitigative measures that avoid or minimize impacts.

Animal populations are considered by many experts to provide an unreliable basis for evaluating fish and wildlife impacts. Sampling errors, cyclic fluctuations of populations and the lack of time-series data all contribute to the problem. Therefore, FWS feels that determining habitat value provides a better basis for

developing mitigation recommendations. But the use of population information is not foreclosed. In fact, concern for potential population losses led to the formulation of the general policy to seek to mitigate all losses to fish, wildlife, their habitat, and uses thereof. The FWS believes that mitigation of potential population losses is a necessary aspect of this policy.

The FWS mitigation policy mirrors the consideration of mitigation as required by the CEQ regulations (40 CFR 1502.14, 1502.16, 1505.2(c) and 1508.20). It sets out goals and planning guidance for the development of FWS mitigation recommendations. The policy does not require absolute strict adherence to a required standard.

The discussion of mitigation in Chapter VI has been revised and expanded to clarify the use of the FWS mitigation policy in establishing mitigation goals and developing mitigation recommendations.

2. Concern was expressed that many mitigation measures imposed on industry at Prudhoe Bay were found to be unnecessary, ineffective, or, in some cases, detrimental to the environment. Blanket restrictions were viewed as inefficient and less desirable than mitigation measures based on case-by-case evaluations.

Some mitigation measures originally imposed on frontier oil and gas development activities at Prudhoe Bay either have been ineffective or have been found to be unwarranted. Preventive techniques are continually being improved with advances in state-of-the-art technology and additional biological data on the effects to fish and wildlife from various development activities in the Alaskan Arctic. Mitigation measures must be viewed in the light of past experience and present technology. Flexibility should also be maintained to rescind or add mitigative measures as determined necessary on the basis of day-to-day experience. This approach was reflected in the draft report/LEIS and is reaffirmed in the final.

3. A number of comments expressed concern that, in evaluating potential impacts of oil development in the 1002 area, the report relied too heavily on mitigation techniques used in the Prudhoe Bay area. The general theme of these comments was that serious impacts have occurred at Prudhoe Bay, in spite of mitigation measures, and that impacts of similar activities might be greater in the 1002 area.

Experience gained at Prudhoe Bay has been relied on as a basis for evaluating impacts where appropriate. Parallels relative to certain types of activities are obvious; that is, many studies contain

conclusive evidence of impacts that will occur under certain conditions or circumstances, regardless of location. On the other hand, there are dangers in drawing analogies where conditions, potential scenarios, or habits of affected species are significantly different. The text in Chapter VI has been modified to emphasize this point and to more clearly explain the rationale for the use of FWS mitigation policy as a means for determining potential loss of habitat values as a basis for impact measurement and evaluation.

It is unrealistic to expect that all impacts will be ameliorated or that there may not be unavoidable impacts having significant adverse effects. For example, potential impact on wilderness values is perhaps the most significant adverse impact likely to occur, as well as the least possible to effectively mitigate.

Section 1002(h) of ANILCA does not require "no significant adverse impact" as a standard for further oil exploration and development, as was used in the previous seismic exploration program on the 1002 area. It does require "an evaluation of the adverse effects that the carrying out of further exploration for, and the development and production of, oil and gas within such areas will have on the resources." Although there is a risk of significant population declines for PCH caribou and muskoxen, the likelihood of these "catastrophic consequences" is very low. Also, such consequences would not be permanent, because most perturbations would disappear with depletion and shutdown of oil activities and the restoration of the coastal plain (primarily removal of infrastructure).

4. A number of respondents felt that the draft report did not adequately acknowledge the mitigative effects of existing regulatory programs of Federal, State, and local governments having jurisdiction over the 1002 area.

We believe that the importance of these controls is adequately recognized in the report, although some additional information has been provided. We generally believe it (1) unnecessary to belabor well-known regulatory processes and (2) more important to focus on areas where additional mitigation may be necessary to ensure that refuge resources are not subject to unnecessary adverse effects.

5. Although a number of comments were critical of the draft LEIS/report in not adequately acknowledging the mitigative effects of existing regulatory programs, an almost equal number voiced concern that existing regulations, standards, and stipulations are inadequate to ensure mitigation.

As stated in Chapter I, more than 36 Federal laws, 5 State of Alaska laws, and 111 separate regulations currently apply to oil and gas activities in Alaska. The FWS believes that these laws and regulations provide ample guarantee for protection of the resources of the 1002 area. Laws such as ANILCA and the National Wildlife Refuge System Administration Act give additional controls to FWS which are lacking on nonrefuge lands.

WATER AVAILABILITY AND DEVELOPMENT

A variety of comments were received regarding 1002 area water supplies large enough to support oil and gas exploration and development. The following information is expanded on in the final report.

The limited availability of fresh water on the Arctic coastal plain is not unique to the 1002 area, nor has it precluded development. Sources used and methods developed to satisfy water requirements in other areas in the Arctic would apply to activities in the 1002 area. Solutions to providing/obtaining water would be considered on a site-by-site basis. Sources and methods used to obtain winter water supplies in earlier exploratory development and production activities in Arctic Alaska are discussed in Chapter II of the report.

AIR QUALITY

Many commenters criticized the lack of information and analysis of effects regarding air quality in the draft report. Additional information has been made available to the Department, and expanded discussions have been included in Chapters II and VI. Several issues were raised:

1. One commenter indicated that the draft LEIS should include a discussion of the process for regulating air quality in the 1002 area. Another commenter expressed confidence in the current process for regulating air quality in Alaska and suggested that changes were not needed in the regulatory framework.

It is difficult to predict the impacts on air quality in the 1002 area without knowing the scope, timing, and location of oil development. However, the existing regulatory structure is designed to assess the potential effects of oil development on air quality once such critical variables are known. Under this structure, the State of Alaska Department of Environmental Conservation must grant permits prior to any construction on the 1002 area. For significant activities, permits require that major sources of pollution apply best available control technology, that minor sources apply new source performance standards, and that Alaska's control requirements be written into State implementation plans.

2. Several commenters suggested that the final LEIS include results from modeling emissions estimates for the 1002 area.

The Department does not believe that current information permits reliable modeling of the impact of 1002 area oil development on air quality. Moreover, given that the current regulatory structure and the mitigation measures that it requires are adequate, such modeling is unnecessary at this time. Air-quality modeling would be an important component of subsequent deliberations by the State on whether to grant permits for activities in the 1002 area.

3. Several commenters expressed concern about the potential contribution of oil development on the 1002 area to a buildup of carbon dioxide (CO₂) concentration levels in the Earth's atmosphere.

Development in the 1002 area would not lead to a significant increase in the CO₂ concentration in the atmosphere, which could, in turn, via the "greenhouse effect," raise the earth's temperature. This is true for several reasons. First, CO₂ concentration is a global phenomenon. The potential resources on the 1002 area, though sizable, are relatively insignificant in relation to worldwide fossil fuel consumption. Second, if the 1002 area's oil resources are not developed, it is likely that other fossil fuel resources would be developed in their place. Some fossil fuels, such as coal, can have greater air-quality impacts than oil. Third, fossil fuel combustion is only one of the ways which contributes to CO₂ buildup. Fourth, CO₂ is only one of several gases contributing to the "greenhouse effect." Some investigators believe that, over the next 50 years, these other gases may play an equally important role in CO₂ buildup. Finally, there is substantial uncertainty about the likelihood of global warming.

4. Some commenters expressed concern that the impact of oil production on ambient ozone concentrations could be significant and that it should be dealt with in the final report.

Ozone is formed by a complex series of atmospheric reactions between volatile organic compounds and nitrogen oxides in the presence of sunlight. Generally, ozone formation is not expected to be significant in Alaska, and especially in the 1002 area, because the intensity of sunlight and temperatures--two critical factors in the formation of ozone--is quite low.

5. There was some concern that there could be significant effects from acid rain and that this issue was ignored in the draft LEIS.

Chapter VI deals with this issue explicitly. Sulfate deposition is expected to be relatively low even under the 5-percent-probability case. Moreover, data from the Prudhoe Bay vicinity, where the FWS has been measuring pH values of ponds and lakes since 1983, show that these surface waters are neutral or alkaline.

GRAVEL

Several commenters found the implied shortage of gravel in the 1002 area to be somewhat overstated in light of the difficulties encountered with gravel in drilling seismic shotholes during the 1983 exploration season. Also pointed out was the fact that shothole logs and samples from the entire area were made available to the Department. The drillers' logs are not adequate for a detailed geotechnical analysis, but they do indicate the presence of widespread, thick upland and channel gravel deposits. Even though the gravel may not be optimally located for all possible developments in the 1002 area, generalizations about gravel shortages are inappropriate. The text has been revised accordingly.

ENERGY CONSERVATION

Many comments noted the importance of conservation in meeting national energy goals. The Department of Energy is responsible for the development of national energy policy, including means of achieving conservation. The Department of the Interior's role in this energy policy is to comply with its legal mandate to manage the development of energy resources on Federal lands in an environmentally acceptable manner. The focus of this report/LEIS is to respond to the statutory questions about the potential petroleum and biological resources in the 1002 area, not to review the full scope of national energy policy. Conservation and increased domestic production are, of course, complementary components of a broader national energy policy.

USE OF "WORST CASE" ANALYSIS

Many commenters, especially those from industry, criticized the FWS for using a "worst case" analysis in determining environmental effects.

Leasing and development, from field exploration through oil production, transportation, rehabilitation and abandonment, would be sequential on the 1002 area. For purposes of impact assessment, it was assumed that Blocks A, C, and D (for Alternative A) were leased and that exploration was successful. It was further assumed that each of these blocks, plus Block B which would be crossed by the main pipeline, would at some point in time have some concurrent activity, whether it be winter seismic

work; exploration and development well drilling; construction of airstrips, port developments, pipelines; or rehabilitation. If some of the currently prospective areas that were assessed contain no economically recoverable oil (of which there is an 81-percent chance), then predicted impacts would be substantially less, probably limited to those associated only with exploratory well drilling and cleanup. This would be particularly true if delineated prospects in Blocks C and D produced "dry holes." Not only would development of the fields not occur, but the main pipeline could be shortened by a significant amount, and the Pokok port site would be unnecessary. Such speculation, however, precludes meaningful analysis.

Therefore, as required by the Council on Environmental Quality (CEQ) regulations (40 CFR 1502.22) for purposes of impact assessment, oil-related activities reasonably foreseeable at some point in time in the 1002 area were assessed.

The lands under consideration are National Wildlife Refuge System lands, lands that by their designation and through the legislative history have been deserving of special resource protection. Therefore, the impact assessment must clearly provide the Secretary of the Interior the information necessary for his decision as to the recommendation to the Congress. Through such an analysis he can understand and answer the question, "What is the most that can reasonably be expected to happen if the 1002 area is opened to further oil and gas activity; what natural resource risks and tradeoffs are involved?" It does not present analysis and probable conclusions as to what is the worst that can happen. The text has been clarified accordingly.

As further required by the CEQ's regulatory amendments (40 CFR 1502.22(b)(3) and (4)), Chapter VI summarizes existing credible scientific evidence relevant to evaluating reasonably foreseeable significant adverse impacts, based upon theoretical approaches or research methods generally accepted in the scientific community. There is substantial uncertainty about the ability of wildlife in the 1002 area to adapt to oil activity or to seek out other appropriate habitats. In the report, the FWS has taken special care to identify areas of biological uncertainty. Biological conclusions that can not be drawn with certainty have been noted as speculative.

The report also recognizes, and in fact places some assurance on, the ability and willingness of the oil industry to work with State and Federal regulatory and management agencies in consolidating facilities and developing other mitigating technology and techniques for environmentally acceptable Alaska North Slope operations. Even with this assurance it cannot be assumed that oil and gas activities on the 1002 area will not result in population declines, changes in distribution, or behavioral changes in certain wildlife species which use the 1002 area for critical segments of their life cycles.

CUMULATIVE EFFECTS

A number of individuals commented that the potential cumulative effects of oil and gas leasing and other development activities within the Canadian and Alaskan Arctic regions had not been fully addressed. In response to these concerns, a section on cumulative effects has been added to Chapter VI. The discussion of this issue is brief, because the programmatic LEIS/report is intended to focus on the 1002 area and the specific natural resource questions raised by the Congress. The issue of cumulative effects would be addressed in detail as part of the comprehensive environmental reviews that would be required if the Congress authorizes the leasing of oil resources within the 1002 area.

OIL SPILLS

The Alaska Oil and Gas Association, by telegram, expressed its concern about the 23,000 oil spills referenced in the draft report. They contended that this number of spills appeared to be erroneously attributed to the North Slope alone, and asked that the information in Chapter VI be verified. The figure was obtained through staff communications between the FWS and the Alaska Department of Environmental Conservation, which advises now that the information cannot be verified without extensive record reviews. Therefore, the reference to 23,000 spills has been removed from the final report, and the discussion clarified.

Socioeconomic Issues (Chapters II and VI)

SOCIOCULTURAL CONCERNS

Concerns that the sociocultural issues were ignored in the draft have been addressed. A section on "Sociocultural System" has been added to Chapters II and VI, and the "Socioeconomic" environment has been retitled the "Human" environment. The importance of cultural values from activities such as subsistence, accelerating changes to traditional Native activities, and potential benefits of increasing social services are discussed in the new sections.

Canadian government entities and some villages were concerned that the potential impacts on Canadian Native subsistence opportunities had not been adequately considered. The discussions have been expanded in Chapters II and VI.

RECREATIONAL USE

A few commenters wanted precise statistics concerning recreational use of the area. Precise data on the average number of recreational visits to the 1002 area are not available. Best estimates for recreational use are presented in Chapter II. As stated in the report, data on the number of unguided recreational users is not available. A comparison with other areas of the State would have little meaning. Special-use permits are issued only for commercial activities or "nonprogram" uses (50 CFR 27.97 and 29.3). They do not reflect the number of recreational users visiting the coastal plain, because recreational hunters, fishermen, backpackers, hikers, rafters, etc., do not need permits. A summary of the number of permits issued per year would be a poor index to the actual recreational use of the 1002 area.

WILDERNESS REVIEW

A few commenters were concerned about a perceived lack of wilderness review as a part of the report/LEIS.

Section 1002(h) does not require a wilderness review pursuant to the Wilderness Act. The public land order that established the Arctic National Wildlife Range recognized the wilderness values of the range, including the 1002 area. The Congress recognized this again in 1980 when it passed ANILCA, as well as recognizing the possibility that large quantities of oil and gas may exist on the 1002 area. It excluded the coastal plain from the area within the Arctic Refuge that it did designate as wilderness, pending consideration of the 1002 area study and further congressional action. Nonetheless, this report/LEIS evaluates a wilderness alternative to comply with NEPA.

COMPLIANCE WITH TITLE VIII

Section 810 of ANILCA requires, prior to any Federal agency determination to withdraw, reserve, lease, or otherwise permit the use, occupancy, or disposition of public lands under any of the provisions of the law authorizing such actions, that the head of the Federal agency evaluate the effects on subsistence uses and needs. Although subsistence uses and needs were identified, and the impacts assessed as part of the draft LEIS/report, the Department of the Interior did not conduct a formal 810 evaluation.

This final LEIS/report represents recommendations for legislative action, rather than a determination under existing provisions of law. Formal procedural requirements pursuant to Section 810 are not required to be met at this point in time. If, however, the Congress decides to open all or part of the 1002 area to oil and gas leasing, formal 810 Evaluations and Findings would be conducted. The statute requires that if such an evaluation resulted in a finding of

significant restriction to subsistence uses and needs, public hearings would be conducted in the vicinity of the 1002 area. If further determination is made that the significant restriction is necessary, the statute requires that the minimum amount of public lands must be considered, and steps to minimize adverse impacts to subsistence must be assured.

Oil and Gas Resource Assessment Issues (Chapters III and VII)

MARGINAL PROBABILITIES FOR COMMERCIAL HYDROCARBON OCCURRENCE

Several comments indicated a misunderstanding of the term marginal probability, as defined as an output of the PRESTO model. The text of Chapter III has been revised and expanded at several points to clarify the definition generally, and the derivation and significance of the marginal probability reported for the 1002 area. The effect of the minimum economic field size on the marginal probabilities of occurrence generated by the PRESTO model cannot be overemphasized, particularly for remote, high-cost frontier areas such as the 1002 area.

As noted in the revised text, the reported 19 percent or a "one in five" chance for the 1002 area can hardly be characterized as a "high risk" when viewed in the context of the statistical success rates for discoveries of significant size, to say nothing of the field sizes expected in the 1002 area. The statement that there is a 19-percent chance of finding recoverable oil in the 1002 area needs to be interpreted in the context of past experience in oil exploration and resource assessment. Generally speaking, the chance of oil's being present will be lower, the smaller the unexplored area being considered. The 19-percent chance for the 1.5-million-acre 1002 area thus indicates a very high potential when compared to the 27-percent chance for the 37-million-acre Navarin Basin or the 22-percent chance for the 70-million-acre St. George Basin (table III-1).

The text in Chapter III has been revised to include references to probability of occurrence where appropriate.

SMALL AND UNIDENTIFIED PROSPECTS

Several commenters expressed concern that the economically recoverable resource estimate does not adequately account for potential resources in unidentified prospects, and in the smaller identified prospects.

With respect to unidentified prospects (stratigraphic traps and structures smaller than the seismic grid), the text has been expanded to emphasize the concept that the recoverable estimate represents an "identified minimum" volume.

The PRESTO model does include resources from small, apparently subeconomic, prospects on those Monte Carlo simulation passes where optimum values for volumetric parameters are sampled from the distributions. Naturally, this occurs less often for smaller prospects, and so their relative contribution to the aggregate area resource is less than for larger prospects. Also, the "most favorable case" economic scenario (table III-3) provides some idea of the effect of lower costs and lower minimum field sizes.

PROBABILITY DISTRIBUTIONS

Some comments indicate a lack of understanding of the manner in which both the in-place and recoverable resource estimates are presented.

Owing to the uncertainty inherent in all oil and gas resource estimates, current and almost universal practice is to use ranges of values for many of the input variables which affect the volume of resources in a geologic play or prospect, and to report the results as a range of values with an associated probability distribution.

Three "measures of central tendency" are associated with probability distributions. These are the mode, the median, and the mean. For the purposes of characterizing a resource distribution curve, the mean is considered most appropriate, because it takes into account the size, as well as frequency of occurrence, of values in the range. Technically, the "most likely" value, or mode, is the value which occurs most frequently in the range, not the lowest value as suggested by one commenter. The median is simply the midpoint in the range.

GEOLOGIC RISK

The discussion of area, prospect, and zone risk factors used for the Recoverable Resource analysis has been revised and expanded, as has the discussion of marginal probabilities. This will clarify the crucial differences between prospect and area risk factors, and between input risk factors and output marginal probabilities.

EXISTENCE OF THE ELLESMERIAN SEQUENCE

A number of comments focused on the question of the presence or absence of Ellesmerian sequence rocks, particularly the Ivishak Formation, in the subsurface in the 1002 area. Certainly, as has been pointed out by several commenters, the seismic data alone cannot conclusively resolve this question. Nevertheless, the data do provide some basis for considering the possibility in a more favorable light than in the 1980 resource assessment.

As noted in the description of structure in Chapter III, the only horizon which can be mapped with any semblance of continuity across the entire 1002 area is the top of the pre-Mississippian basement complex. In many

parts of the area, parallel and locally continuous reflectors are associated with the mapped horizon, indicating substantial thicknesses of stratified rocks which have different structural characteristics from the overlying, intensely deformed Brookian rocks. Some limited reprocessing and detailed analyses of seismic data from the eastern part of the 1002 area indicate a similarity in character to reflectors known to be associated with Ellesmerian rocks west of the Canning River.

Uncertainty about the existence of the Ellesmerian sequence was accounted for in risk factors applied to pertinent play and prospect attributes. Uncertainty about quantitative attributes was accounted for in the ranges of values used for volumetric parameters, and reflected in the range of resource estimates.

TABLE III-1 (OCS PLANNING AREAS)

Several comments suggested that marginal probabilities for commercial hydrocarbon occurrences for OCS planning areas and for the 1002 area be added to table III-1. The table has been modified to show conditional resource estimates for unleased areas only, and the marginal probabilities have been added. The source for OCS estimates is Cooke (1985).

The information in table III-1, as revised, may be subject to misinterpretation unless certain considerations are kept in mind:

1. For areas where a commercial discovery has occurred, no matter how small, the marginal probability for occurrence of commercial hydrocarbons is by definition 100 percent.
2. For OCS planning areas, some of the reported marginal probabilities may be based on the probability of occurrence of commercial gas accumulations. For the 1002 area, only oil was considered.
3. The relatively high marginal probability for the Beaufort Sea planning area may be a consequence of a "potentially commercial accumulation" at Seal Island (Cooke, 1985, p. 33), which extends into the planning area. If the planning area were subdivided, it is very unlikely that the eastern Beaufort Sea offshore from the 1002 area would have such a high probability for commercial hydrocarbons.
4. In making comparisons between the areas shown in table III-1, both the volume of resource and the probability of occurrence should be considered (see Cooke, 1985, p. 13).
5. Planning areas are different sizes; the larger the area, the greater the likelihood that hydrocarbons will be present.

FIGURE III-2 (PROSPECT SIZES)

A number of comments indicate some confusion about the intent and proper interpretation of the graphic field size comparisons shown in figure III-2.

Figure III-2 is not intended to imply that undrilled prospects in the Arctic Refuge are directly comparable to proven fields. The purpose of figure III-2 is to illustrate the range of possible prospect resources in terms of known quantities that a layman can relate to. The caption for the illustration has been revised to reflect probabilities associated with the 1002 prospect resources.

Some commenters apparently have equated the solid black pattern (95-percent probability range) for the 1002 prospects with the same pattern for proven fields. The pattern has been changed to avoid this confusion.

The text discussion of prospects shown in figure III-2 has also been revised to reflect probabilities of occurrence.

DATA CONFIDENTIALITY

A few commenters were concerned by what they perceived to be a failure to release for public review and comment the geologic information critical to the assessment process. The subsurface seismic information was collected by a permittee--Geophysical Service Inc. (GSI)--and submitted to the U.S. Government under 50 CFR Part 37. It is protected under these regulations which require the Government to hold confidential or proprietary the geologic data collected by a permittee on the 1002 area.

Analysis in the report is based on government-processed data resulting from processing industry's raw data (seismic tapes). The Department will make raw data available to the public after the report is formally submitted to the Congress, pursuant to regulations (50 CFR Part 37.54). Industry-processed, analyzed, and interpreted data obtained as a result of exploration activities by the permittee or a third party will not be released to the public until 10 years after the submission of such data or information, or until 2 years after any lease sale, whichever period is longer, in accordance with the regulations.

The volume of geologic data and the proprietary nature of the seismic data precluded including all data in the Chapter III summary of the geology of the 1002 area. Scientists of the GS and BLM reviewed all the data to present this condensed report for the government and the public. A more comprehensive technical report (USGS Bulletin 1778) will follow later this year.

Conversely, GSI's comments focused on what they perceived to be a breach of the regulations concerning some of the data and level of detail in Chapter III and the accompanying plates. Because of continued concern from

members of the GSI participant group, the Department thoroughly reviewed its data confidentiality policy during 1986, and the regulations implementing the exploration program (50 CFR Part 37). The review led the Department to reaffirm its previous decision that the government-processed data (government seismic record sections) are not required to be withheld pursuant to 50 CFR 37.54(a). Data in the report are based entirely on government-acquired information, and raw data (seismic tapes) acquired by GSI.

OIL PRICES

Many commenters questioned the assumptions regarding oil prices used for economic analyses which are the basis for the minimum economic field size estimates in Chapter III.

Oil price assumptions used in the economically recoverable resource analysis were developed for the year 2000 and beyond, when crude oil production from the 1002 area was forecast to begin. Therefore, these prices are not directly comparable to current crude oil prices. The \$33 per barrel (1984 dollars) oil price assumed in the most likely case analysis for 1002 area crude oil was set at an intermediate level from the range of future oil prices projected in numerous price forecasts. These forecasts were conducted by the Department of Energy (DOE); private research firms, such as Data Resources Incorporated; and several oil companies such as Chevron Corporation, Texaco, Conoco, and Ashland Oil, and were the latest available at the time the analysis was completed. Recent, unpublished DOE projections indicate an 8-percent reduction from DOE estimates available at the time the analysis was completed.

A complete and thorough discussion of the sources of oil price forecasts and related assumptions is included in Young and Hauser (1986).

OIL PRICE GROWTH RATE

Several comments suggest that the rate of increase in oil prices used in the report should be the same as used by the U.S. Minerals Management Service (MMS).

In the recently published MMS 5-year Outer Continental Shelf Oil and Gas Leasing Program for 1987, the starting oil prices ranged from \$9 to \$34, in 1987 dollars. The year 2000 prices ranged from \$10 to \$45, in 1987 dollars. The \$33/barrel price (1984 dollars) used in this LEIS clearly falls within that range when the MMS figures are adjusted to 1984 dollars. The figures used herein are thus consistent with the MMS figures.

NATURAL GAS

Comments on the subject of natural gas resources in the 1002 area fall into two categories:

1. Section 1002, NEPA, and CEQ require an assessment of the environmental effects of exploration for and development of natural gas, as well as oil.
2. The potential significance and future value of natural gas deposits are not adequately addressed.

With respect to the first concern, exploratory wells in the 1002 area could encounter dry gas, oil, oil with associated gas, or water. The impacts of exploratory drilling would be the same regardless of what is found. The effects of natural gas development and production would be somewhat less intensive than for oil, due to wider well spacing and smaller production facilities, but would involve virtually the same surface area. That is, for the purposes of impact analysis, the same prospects would be considered. In the unlikely event that only gas would be produced from the 1002 area, impacts associated with a trunk pipeline would likewise be less, inasmuch as "hot oil"/permafrost engineering problems would not be a factor. It might be possible to bury a gas pipeline over most of its length. Concurrent development and production of oil and gas from the same prospect and the area would have roughly the same impacts as for oil alone, as was pointed out in the draft report.

With respect to the second concern, the method used for the estimation of economically recoverable resources in the 1002 area requires the estimation of a minimum economic field size for each prospect, which in turn, requires demonstration of a positive net present value. Given the current economics of North Slope natural gas, and the immense proven gas reserve base elsewhere, natural gas from the 1002 area simply cannot be demonstrated as having any present economic value using standard discounted cash flow procedures. See Young and Hauser (1986) for a complete discussion of natural gas economics for the 1002 area.

ECONOMIC SCENARIOS

Several commenters expressed the opinion that a "pessimistic" or low-side recoverable resource assessment should be included based on lower oil prices, as well as the "optimistic" or "most favorable" case.

Sensitivity analyses were conducted to determine effects of variations in several economic parameters, including oil prices, on the economics of "typical" prospects in the western and eastern parts of the 1002 area. The lowest oil price modeled was \$22/barrel (year 2000 price, 1984 dollars). The minimum economic field size for the eastern 1002 area prospect using this price is over

2 billion barrels (recoverable). For the western 1002 area prospect, the minimum field size would be about 1.4 billion barrels. Minimum field sizes for actual prospects in the 1002 area, using this price, were not estimated, but it is likely that the minimum for the area would be close to that for the "typical" western prospect (1.4 BBO). All else being equal, the effect of this would be to lower the marginal probability for commercial hydrocarbons from the 19-percent "most likely" case.

National Need Issue (Chapter VII)

MARGINAL PROBABILITIES AND THE NATIONAL NEED

Many commenters suggested that the National Need analysis in Chapter VII is misleading, and that projected economic benefits are overstated, because the analyses are based on conditional recoverable resource estimates.

The economic and domestic supply benefits described in Chapter VII (and the environmental consequences of development described in Chapter VI) are conditional on the discovery of commercial quantities of oil in the 1002 area.

The purpose of estimating economically recoverable hydrocarbon resources was to provide a basis for assessing possible environmental and socioeconomic effects of development, and for projecting potential economic benefits of developing. For the 1002 area, the Congress specifically requires an evaluation of how the potential resources of the area relate to domestic oil and gas supply-and-demand projects. None of these types of analyses can be conducted using risked resource estimates.

Other Issues

CONSULTATION AND COORDINATION

The North Slope Borough and a few other commenters expressed concern that there appeared to be no specific mechanisms outlined in the report to ensure public involvement in Federal decisionmaking concerning development of the 1002 area.

Chapters I, IV, V, and VI recognize the existing statutes that require coordination and consideration during the various stages of development, if the 1002 area is opened for oil leasing. It would be premature to outline specific measures at this point in the process. The final LEIS/report provides a broad, programmatic discussion of management options for the Congress to consider.

This report is not intended to be, nor should it be used as, a local planning document by potentially affected communities. The facility locations and transportation scenarios described in this LEIS represent very broad

assumptions that were made as a basis for identifying characteristic activities and any resulting environmental effects. These assumptions do not represent a Department of the Interior recommendation, preference, or endorsement of any facility, site, or development plan. Local control of events may be exercised through planning, zoning, land ownership, and applicable State and local laws and regulations.

If the area is eventually made available for further exploration or leasing, site-specific NEPA compliance, and compliance with sections of ANILCA and numerous other Federal, State and local requirements, would ensure full coordination with all entities that would be affected.

CONSULTATION WITH CANADA

The Canadian Government was concerned that consultations had not been adequate. The following information leads the Department of the Interior to conclude differently:

The Canadian Wildlife Service (CWS) and its Yukon Wildlife Branch independently conducted studies of the Porcupine caribou herd (PCH) during 1978-81 relative to potential oil and gas developments in the Yukon Territory and Northwest Territories. In conducting the studies for preparation of the baseline reports and the Report to Congress, the FWS worked closely with biologists from the CWS, and the State of Alaska as well.

Before assessing the effects of oil and gas development, production, and transportation in the 1002 area, the FWS conducted a Caribou Impact Analysis Workshop, as explained in Chapter VI of both the draft and final LEIS/reports. Canadian biologists participated at FWS invitation. The forum provided the opportunity for FWS biologists to compare research results and gain valuable information on what impacts the Canadian's own transportation and exploration activities may have had in and near the PCH's migration routes and concentrated calving and wintering areas.

In addition to the technical consultations that have occurred independent of the 1002 process, representatives of the FWS and CWS had been negotiating a PCH agreement for the past several years. This agreement calls for both countries to take appropriate steps to ensure international cooperation and coordination of actions that may affect this internationally shared resource, in order to conserve the species and its habitat. The agreement would establish an advisory board to assist in management. Such an agreement will enhance consultation on future activities.

Once the draft 1002(h) LEIS/report was made available to the Congress and the public for review, the Assistant Secretary of the Interior for Fish and Wildlife and

Parks sent the Embassy of Canada a letter of invitation to consult on the draft report. To date, three consultation sessions have been held--two in Ottawa and one in Washington, D.C. The Government of Canada submitted written comments on the report. The consultations have further provided both countries the opportunity to discuss the biological and geological data upon which the assessments are based, and to address the assessment of potential impacts on the PCH and other internationally shared wildlife resources from possible development activities. Either country may initiate further consultations.

PUBLIC HEARINGS

The Department was criticized for the number of public hearings scheduled. As noted elsewhere in this section, public hearings were held in Anchorage and Kaktovik, Alaska, and Washington, D.C. The hearings satisfied the requirements of the National Environmental Policy Act, and the court's order in Trustees for Alaska, et al., v. Donald P. Hodel that public hearings be held in Alaska and elsewhere. Furthermore, the report was widely distributed and received international media coverage. Most of the media used Interior-prepared press releases and emphasis was placed on the fact that oral testimony and letters of comment submitted through the mail were given equal consideration.

Because the concerns expressed at the three hearings were comprehensive and substantially the same as written comments received, additional hearings would have provided a forum for people to express their opinions, but probably would not have raised any new matters warranting further revision of the report. The Department believes, as was its intent with an LEIS, that the proper forum for this debate is the Congress. The Congress will make the actual decision, after the Secretary's role of analysis and recommendation. There will be ample opportunity for public input during congressional consideration of this report.

SUBMERGED LANDS

The State of Alaska criticized the report for not addressing the ownership status of the beds of nontidal navigable waters. The State asserts ownership of the submerged lands underlying the Aichilik, Jago, Okpilak, Hulahula, Sadlerochit, Staines, and Canning Rivers within the 1002 area. The FWS does not recognize the State of Alaska's claim to these submerged lands. Although the State usually has ownership status for the beds of navigable waterways, the Federal Government claims lands submerged under navigable waters that were reserved to the Federal Government prior to statehood (January 3, 1959). The Arctic Refuge lands were withdrawn for military purposes prior to this date (Public Land Order 82, 1943).

ARCTIC REFUGE LAND EXCHANGE

Several commenters expressed concern about the Department's participation in negotiations with the State of Alaska and with a number of Alaska Native corporations regarding the possible exchange of limited oil and gas interests on the 1002 area for Native and State owned inholdings within other National Wildlife Refuges in Alaska. Of primary concern was the lack of discussion of an exchange and its associated environmental and economic impacts in the draft report.

The determination as to whether the Department would propose such an exchange could not be made until after the Secretary had decided upon his recommendation to the Congress regarding future management of the 1002 area. A discussion of the exchange was not included in the draft or final reports. Exploration and development of State or private oil and gas interests within the 1002 area would be subject to the same regulations and environmental controls as Federal lands in the area, and so the draft and final reports do in effect describe the potential impacts of such operations on Arctic Refuge resources and subsistence use.

Although section 910 of ANILCA exempts land exchanges with Alaska Natives from compliance with the National Environmental Policy Act, the FWS ascertainment reports which would accompany any exchange proposal that may be submitted to the Congress would specifically address impacts of any land exchange on the 1002 lands, as well as on the refuge inholdings to be acquired, and would discuss the economic effects of exchanging limited 1002 area oil and gas interests. The ascertainment reports would also discuss other options considered and the rationale for selecting a land exchange as the means of acquiring Alaska refuge inholdings.

The Department's efforts related to a possible land exchange have been independent of those aimed at preparing and submitting the 1002 report, and have therefore, not compromised the objectivity of the report or the Secretary's recommendation. An exchange agreement will be submitted to the Congress only if the Secretary determines the exchange to be in the public interest. Furthermore, implementation of a land exchange will be contingent upon Congress opening the 1002 area to oil and gas exploration, development, and production, and upon congressional approval of any exchange agreement.

Although an exchange of this nature would create private interests on the Arctic Refuge, it would actually result in a net reduction of private inholdings on Alaska refuges due to the multiple return expected for each acre exchanged on the 1002 area. Also, only subsurface oil and gas interests in the Arctic Refuge would be exchanged. Surface ownership and control would remain vested in the Federal Government. Any exchange agreement would contain such surface use provisions as are necessary to ensure protection of refuge resources and maintain the integrity of the area.

DEVELOPMENT AND TRANSPORTATION SCENARIOS (CHAPTER IV)

Much of the original (draft) description of facilities, equipment, procedures, and practices included in Chapter IV was obtained through consultation with oil companies, from trade publications, or from exploration and development plans and proposals. Most of the comments received on Chapter IV are likewise from oil companies or trade associations and concern recent advancements in technology or alternative technological approaches not considered in the draft LEIS. These comments have been accommodated by minor changes in the text. However, where there is some question as to the universal applicability of an improved or alternative technology cited from the Prudhoe Bay area, the technology is acknowledged in the text as a possibility, but not necessarily endorsed as being applicable for the 1002 area.

DISTRIBUTION OF FINAL REPORT/LEIS

The following have received copies of this final Arctic National Wildlife Refuge, Alaska, Coastal Plain Resource Assessment.

All Members of the United States Congress

Federal Government and Agencies

Advisory Council on Historic Preservation
Alaska Land Use Council
Department of Agriculture
 Cooperative Extension Service
 Forest Service
 Soil Conservation Service
Department of Commerce
 International Trade Commission
 National Marine Fisheries Service
 National Oceanic and Atmospheric Administration
 U.S. Weather Service
Department of Defense
 Alaska Air Command
 Department of Military Affairs
 Naval Arctic Research Laboratory
 U.S. Army, Corps of Engineers
 U.S. Army, Cold Regions Research and Engineering
 Laboratory
Department of Energy
Department of Health and Human Services
Department of Housing and Urban Development
Department of the Interior
 Bureau of Indian Affairs
 Bureau of Mines
 Minerals Management Service
 National Park Service
 Office of the Solicitor
Department of State

Department of Transportation
Federal Aviation Administration
U.S. Coast Guard
U.S. Coast Guard Marine Safety
Environmental Protection Agency
Federal Information Center
General Accounting Office
Marine Mammal Commission
Office of Management and Budget
Office of Technology Assessment

Government of Canada

Embassy of Canada, Washington, D.C.
Ministry of the Environment
Ministry of Indian and Northern Affairs
Department of Energy, Mines & Resources,
Canadian Oil and Gas Lands Administration:
Headquarters, Ottawa
Northwest Territories, Yellowknife
Canadian Wildlife Service
Director General, Ottawa
Pacific and Yukon Regional Director, Delta, B. C.
Secretary of State for External Affairs, Ottawa
Northwest Territories
Department of Renewable Resources, Yellowknife
Yukon Territory
Department of Renewable Resources, Whitehorse
Porcupine Caribou Management Board, Council for
Yukon Indians

Alaska State Government and Agencies

Alaska State Legislature
Office of the Governor (Clearinghouse)
Alaska Oil and Gas Conservation Commission
Alaska State Geological Survey
Alaska State Historic Preservation Office
Attorney General for the State of Alaska
Department of Commerce and Economic Development
Department of Community and Regional Affairs
Department of Environmental Conservation
Department of Fish and Game
Department of Health and Social Services
Department of Natural Resources
Department of Policy Development and Planning
Department of Transportation and Public Facilities
University of Alaska, Geophysical Institute

Alaska Communities

Beaver Village Council
Birch Creek Village Council
Chalkyitsik Village Council
City of Anaktuvuk Pass
City of Arctic Village
City of Barrow
City of Fairbanks

City of Kaktovik
Fairbanks North Star Borough
Kenai Chamber of Commerce
Municipality of Anchorage
Native Village of Eagle
Native Village of Fort Yukon
Native Village of Venetie
North Slope Borough
Rampart Village Council
Stevens Village Council
Venetie Village Council

Alaska Native Groups

Alaska Federation of Natives
Aleut Corporation
Arctic Slope Regional Corporation
Bering Straits Native Corporation
Bristol Bay Native Corporation
Calista Corporation
Chugach Natives, Incorporated
Cook Inlet Region, Incorporated
Doyon Limited
Koniag, Incorporated
NANA Regional Corporation
Sealaska Corporation
The 13th Regional Corporation

Organizations

Akhiok-Kaguyak Village Corporation
Alaska Center for the Environment
Alaska Coalition for American Energy Security
Alaska Conservation Society
Alaska Friends of the Earth
Alaska Oil and Gas Association
Alaska State District Council of Laborers
Alaska Wilderness Council
Alaska Wildlife Alliance
American Petroleum Institute
American Wilderness Alliance
Anchorage Audubon Society
Anchorage Chamber of Commerce
Arctic Audubon Society
Arctic Slope Regional Corporation
Arctic Coastal Zone Manager
Audubon Society, Alaska Region
Canadian Wildlife Federation
Centre for Northern Studies
Defenders of Wildlife
Ducks Unlimited
Dunes Calumet Audubon Society (Indiana)
Environmental Defense Program
Fairbanks Chamber of Commerce
Friends of the Earth
Fund for Animals
Greenpeace
International Association of Fish and Wildlife
International Porcupine Caribou Commission (Alaska)
International North Pacific Fish Commission

Intersea Research Corporation
Izaak Walton League
Kachemak Bay Conservation Society
Kenai Conservation Society
National Academy of Sciences
National Audubon Society
National Park and Conservation Association
National Rifle Association
National Wildlife Federation
National Wildlife Refuge Association
National Wildlife Refuge Association, Anchorage Chapter
Natural Resources Defense Council
Nature Conservancy
North Pacific Fisheries
Northern Alaska Environmental Center
Pacific Legal Foundation
Pacific Seabird Group
Resource Development Council for Alaska
Renewable Resources, Inc.
Rocky Mountain Institute
Rural Alaska Community Action Program, Inc.
Sierra Club
Southeast Regional Resource Center
Steering Council for Alaska Lands
The Real Alaska Coalition
Trustees for Alaska
U.S. Chamber of Commerce
Wilderness Society--Alaska
Wilderness Society (National)
Wildlife Federation of Alaska
Wildlife Management Institute

Industry and Companies

Alaska Biological Research
AMOCO Production Company
ARCO Alaska
Arctic Adventurers
British Petroleum Alaska
British Petroleum Alaska Exploration
British Petroleum North America
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Cities Service Company
CONOCO
Dames and Moore
Drilling Services, Inc.
Esca Tech Corporation
Exxon Company, USA
Geodata Corporation
Geodigit
Geo. Co. of Northway, Inc.
Geophysical Corporation of Alaska
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IMCO Services
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Nissho-Iwai American Corporation

N.L. Baroid Petroleum
Northern Technical Services
Ocean Technology, Limited
Oil Patch of Alaska, Incorporated
Petty Ray Geophysical, Inc.
Phillips Petroleum
Placid Oil Company
Shell Oil Company
Shell Western E&P Inc.
Sohio BP Alaska
Standard Alaska Production Co.
Standard Oil of California
TAM Engineers
Tenneco
Tesoro Alaska Petroleum Corp.
Tetra Tech., Incorporated
Texaco, Incorporated
Union Oil Company
Variance Corporation
Western Geophysical Company
Woodward-Clyde Consultants

News Media

Alaska Journal of Commerce
Alaska Magazine
Alaska Radio Network
Alaska Report
Alaska Review
All-Alaska Weekly
Anchorage Daily News
Anchorage Times
Associated Press
Cheechako News
Christian Science Monitor
Cook Inlet Chronicles
District Media Resource Center
Fairbanks Daily News Miner
Juneau SE Empire
New York Times
Nome Nugget
Northwest Arctic School District
Oil and Gas Journal
Outdoor Writers Association
Peninsula Clarion
Petroleum Engineer International
Tundra Times
USA Today
Wall Street Journal
Washington Post

Others

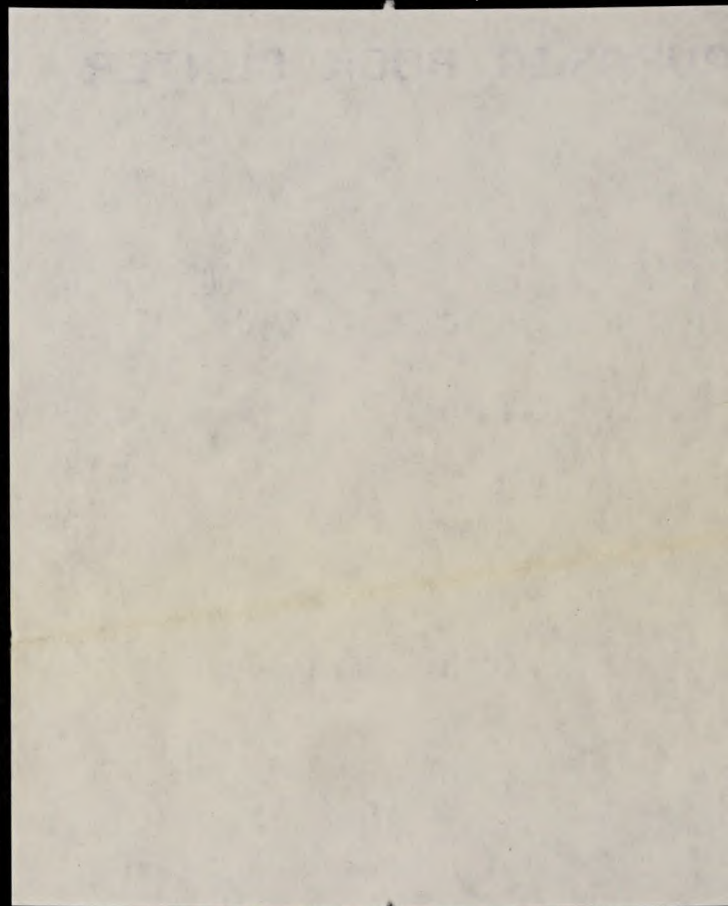
Copies were also sent to State governments, groups, and individuals who made substantive comments on the draft LEIS and to others who had requested to be placed on the mailing list. These recipients are too numerous to list here.

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1987 1002 AREA
 PLATE 3

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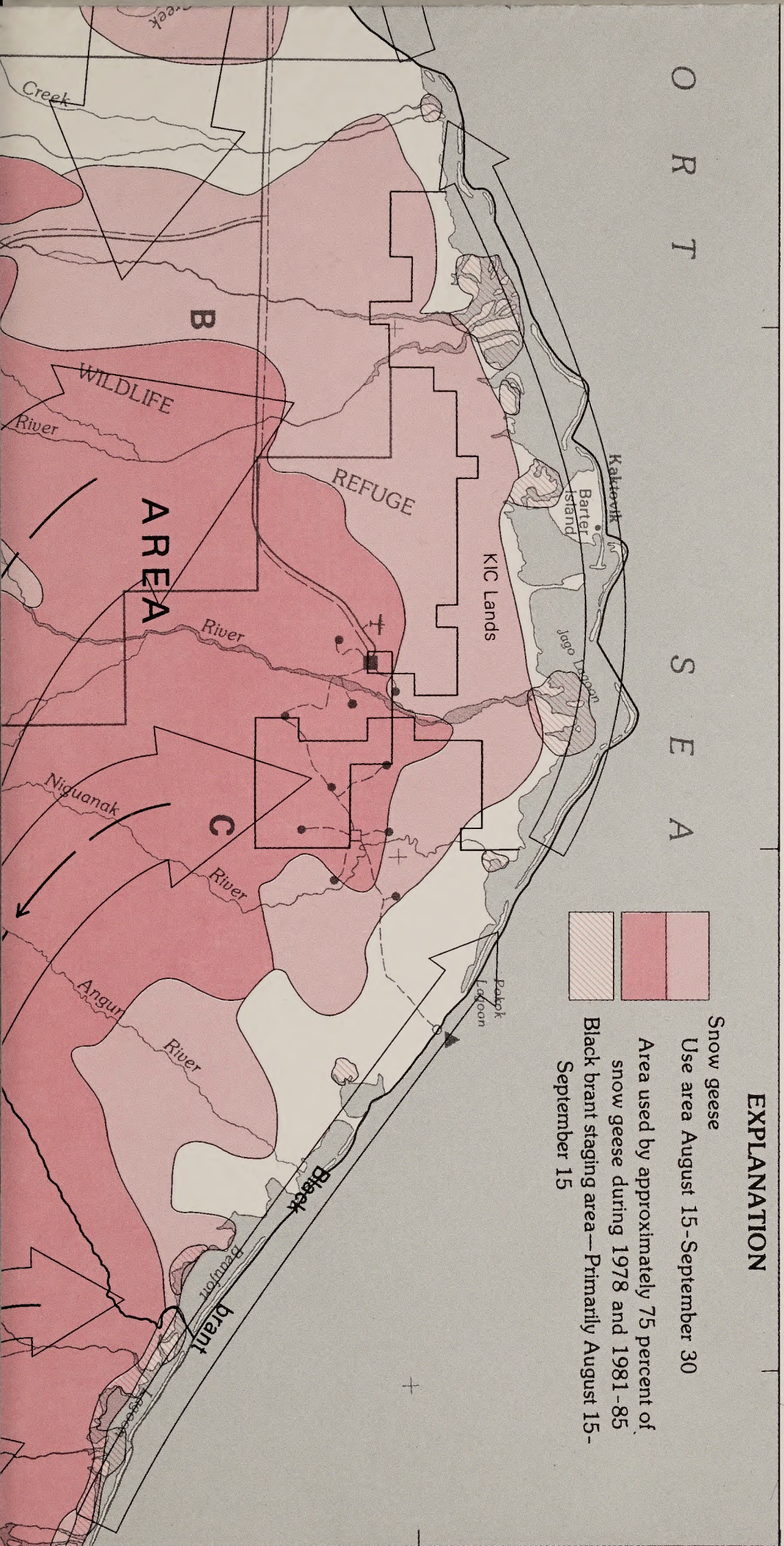
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EXPLANATION



Snow geese
 Use area August 15-September 30
 Area used by approximately 75 percent of
 snow geese during 1978 and 1981-85
 Black brant staging area—Primarily August 15-
 September 15



70°

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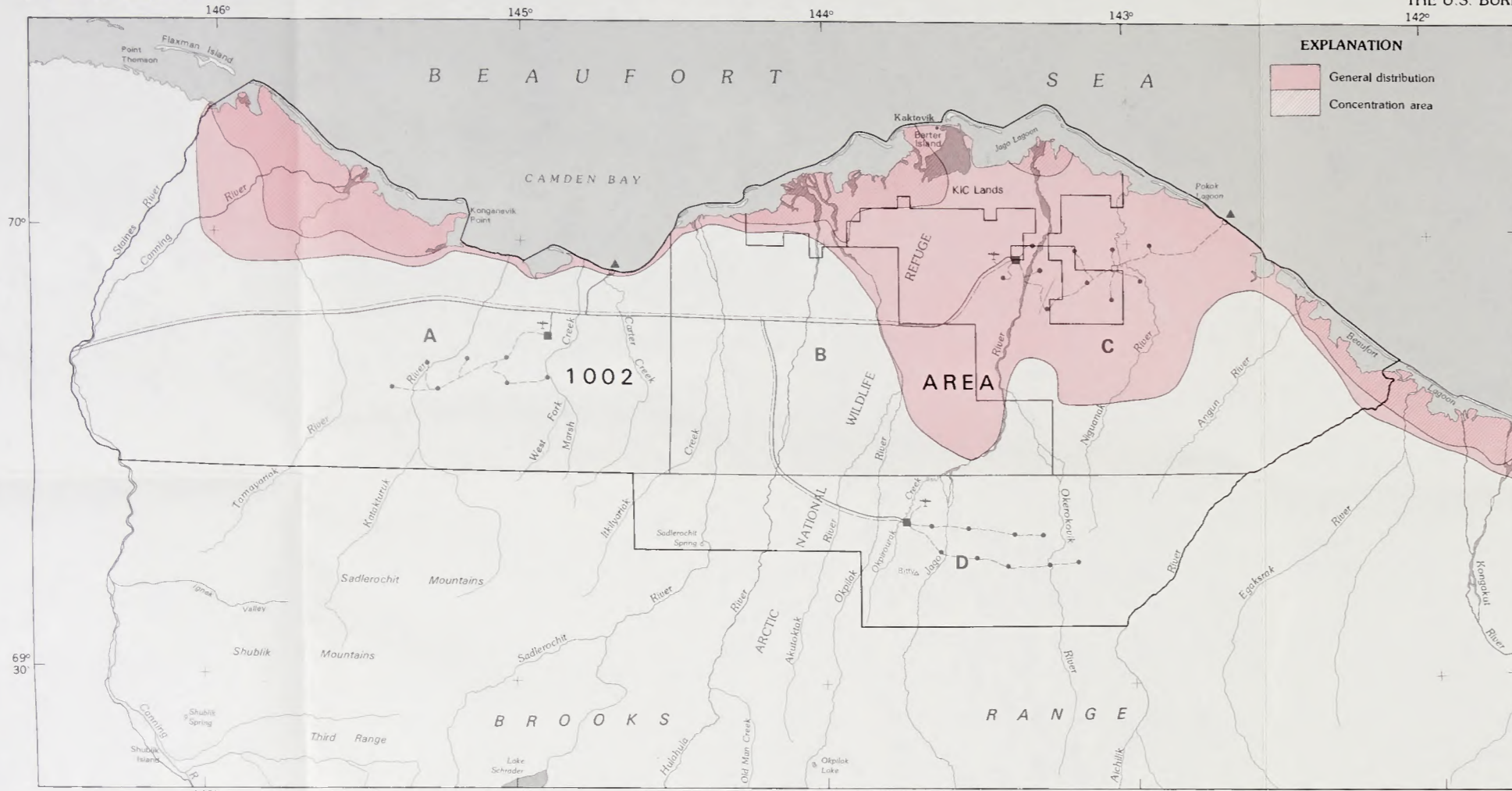
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 aka, Coastal

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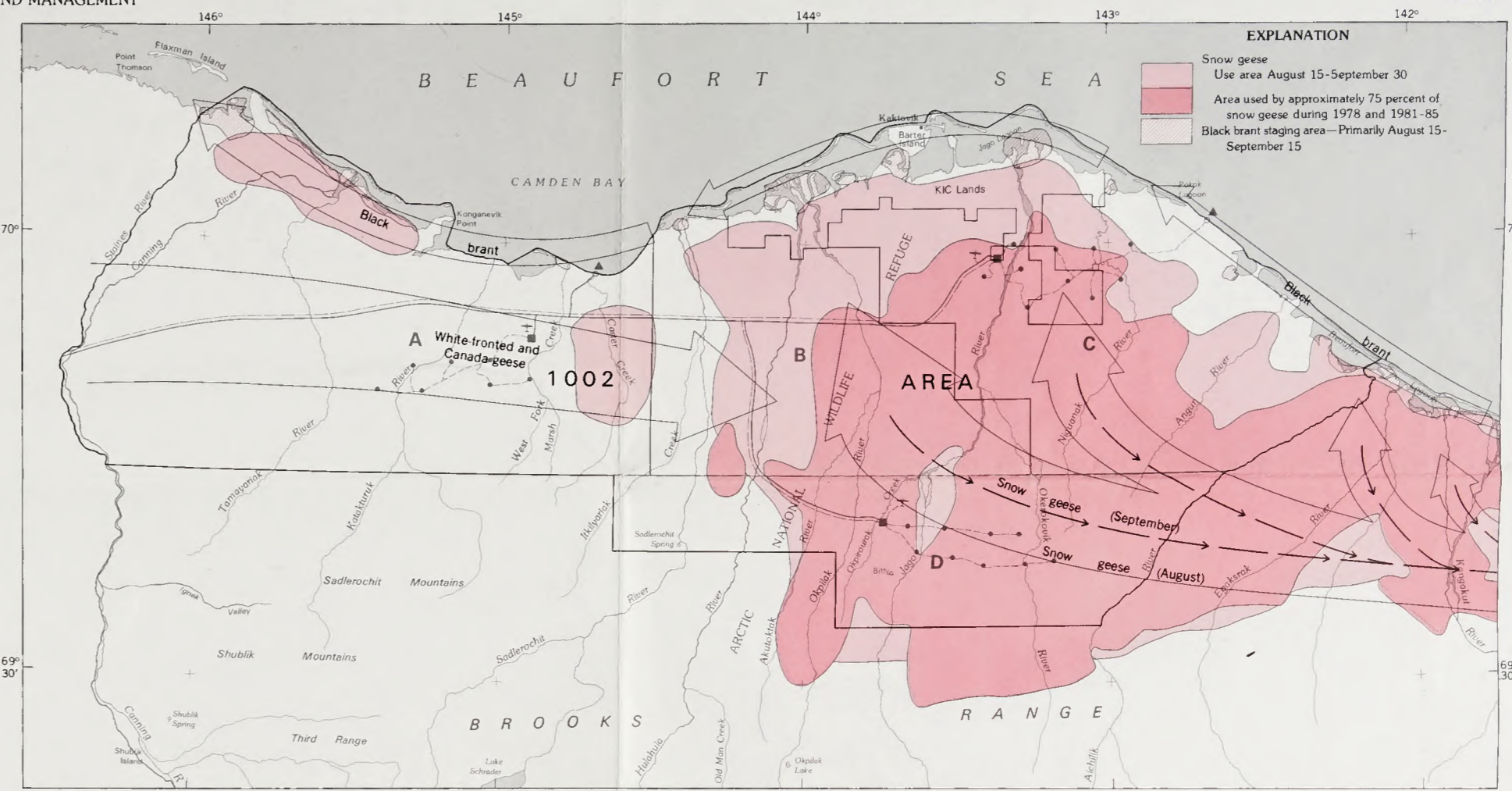
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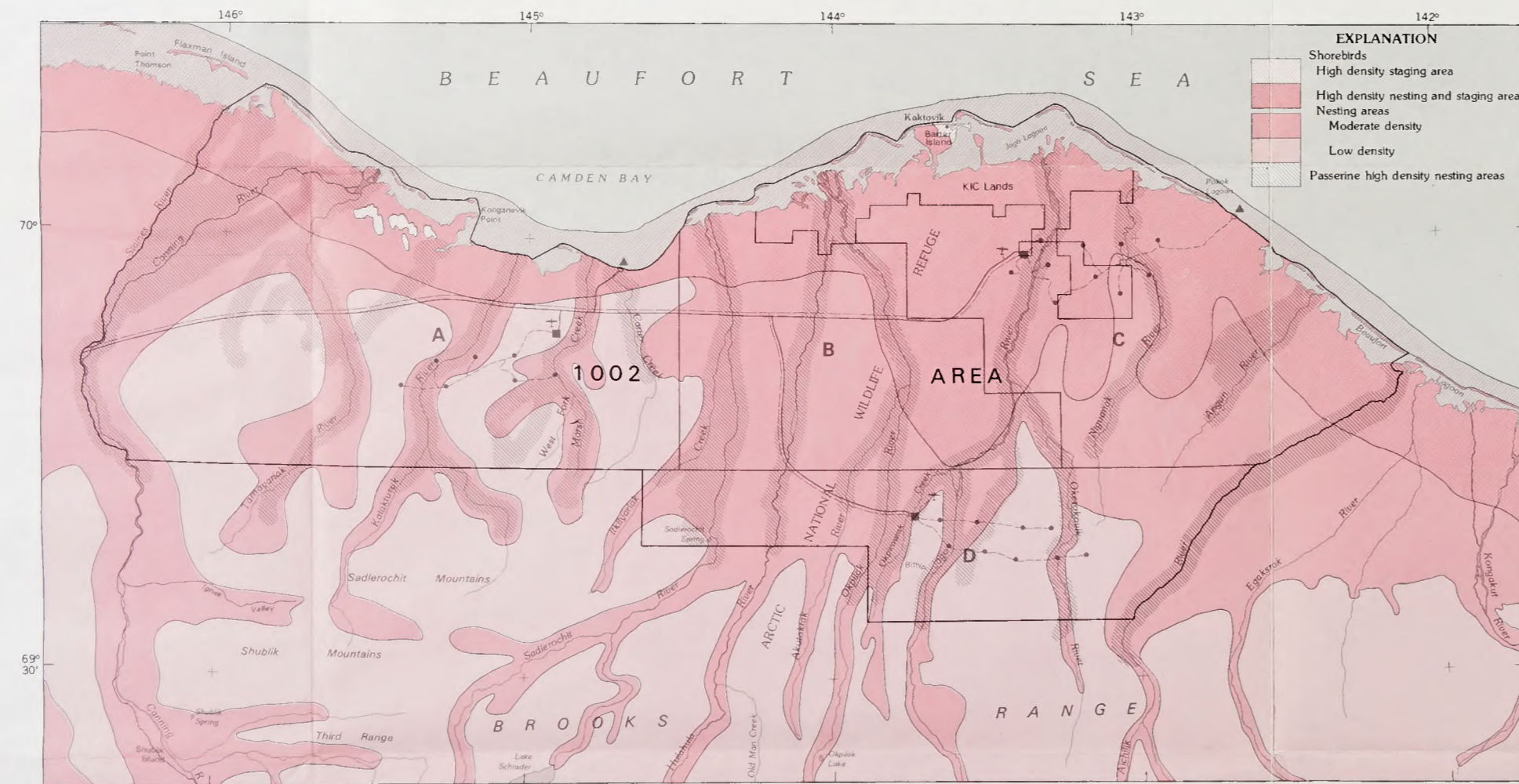
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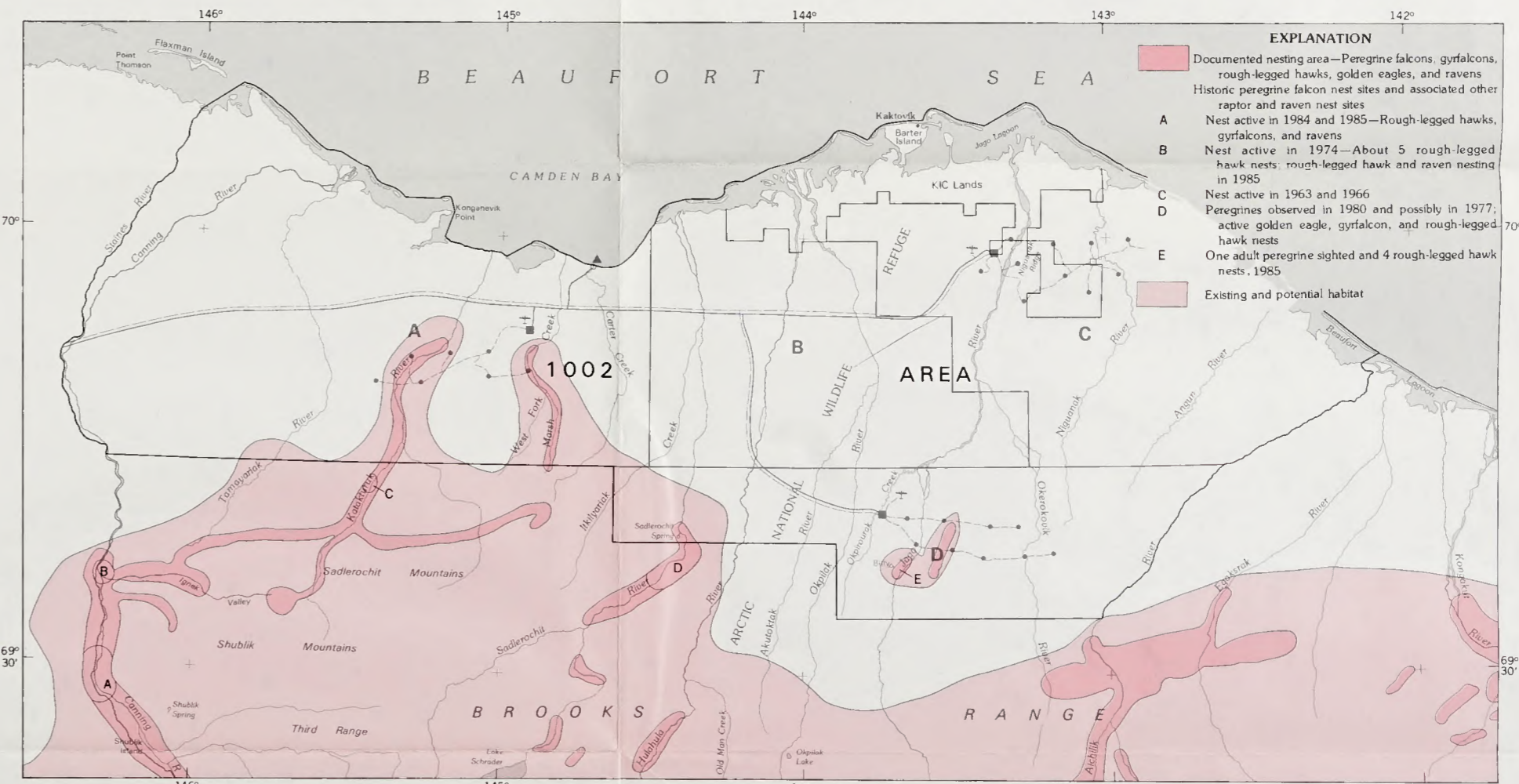
A. Tundra swan



B. Geese and black brant

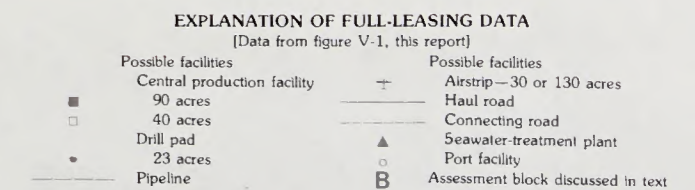
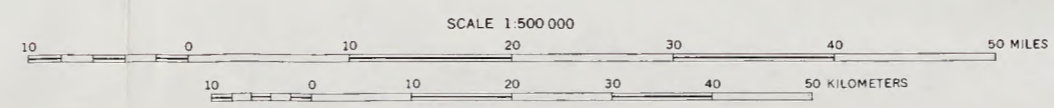


C. Shorebird and passerine nesting and staging areas



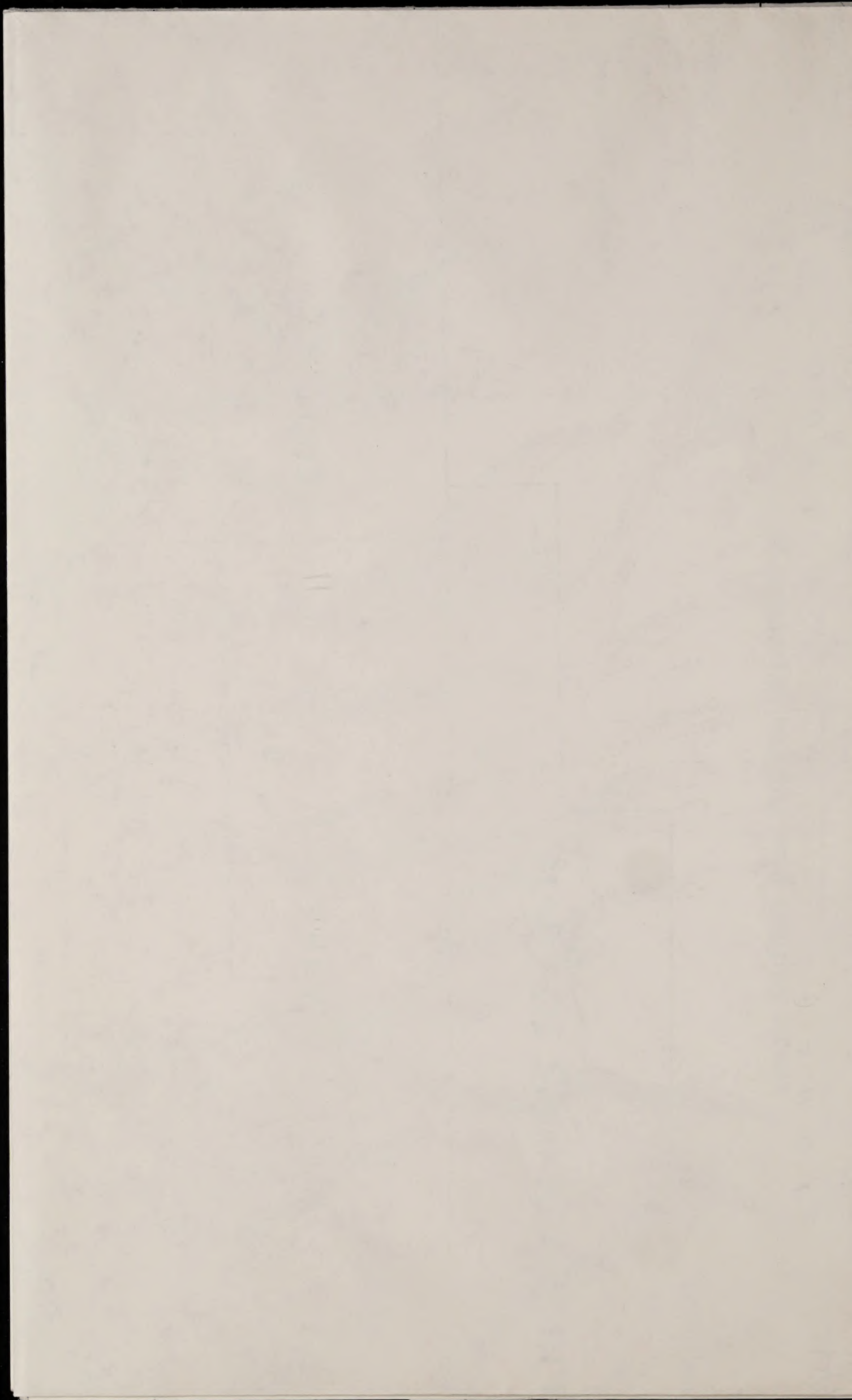
D. Cliff-nesting raptors and ravens

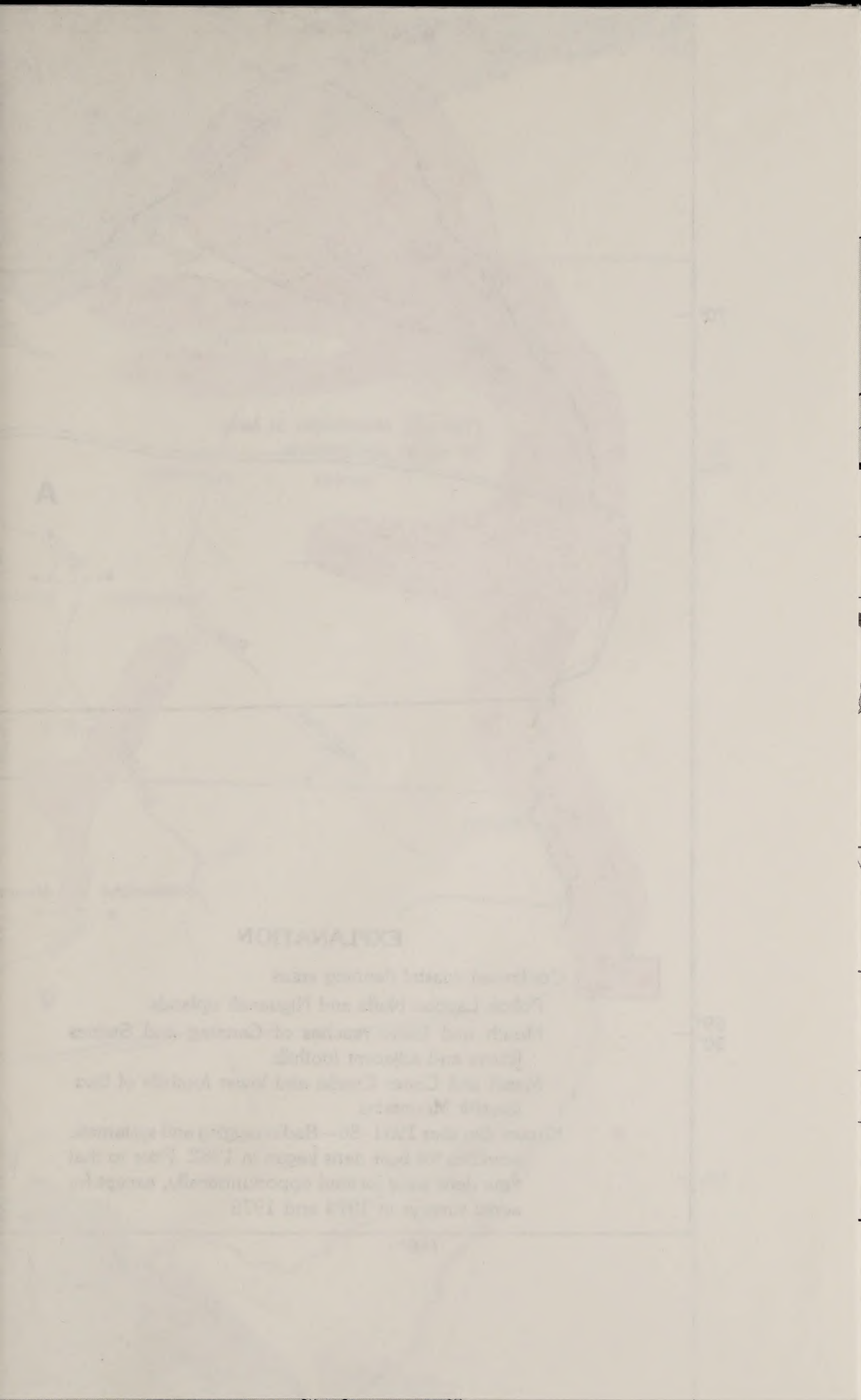
Base from U.S. Geological Survey, scale 1:250,000.
Barter Island, Demarcation Point, and
Flaxman Island, 1955. Limited revision 1983
Mt. Michelson, 1956. Limited revision 1983



MAPS OF BIRD RESOURCES IN THE 1002 AREA, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

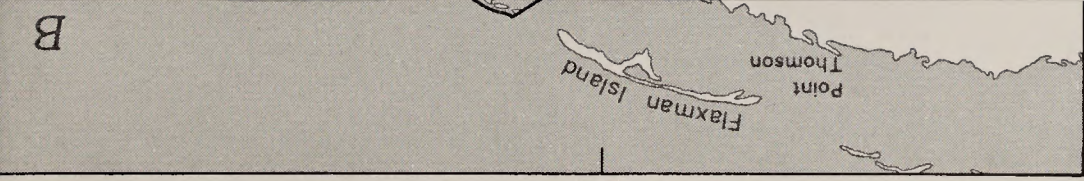
Compiled by the U.S. Fish and Wildlife Service





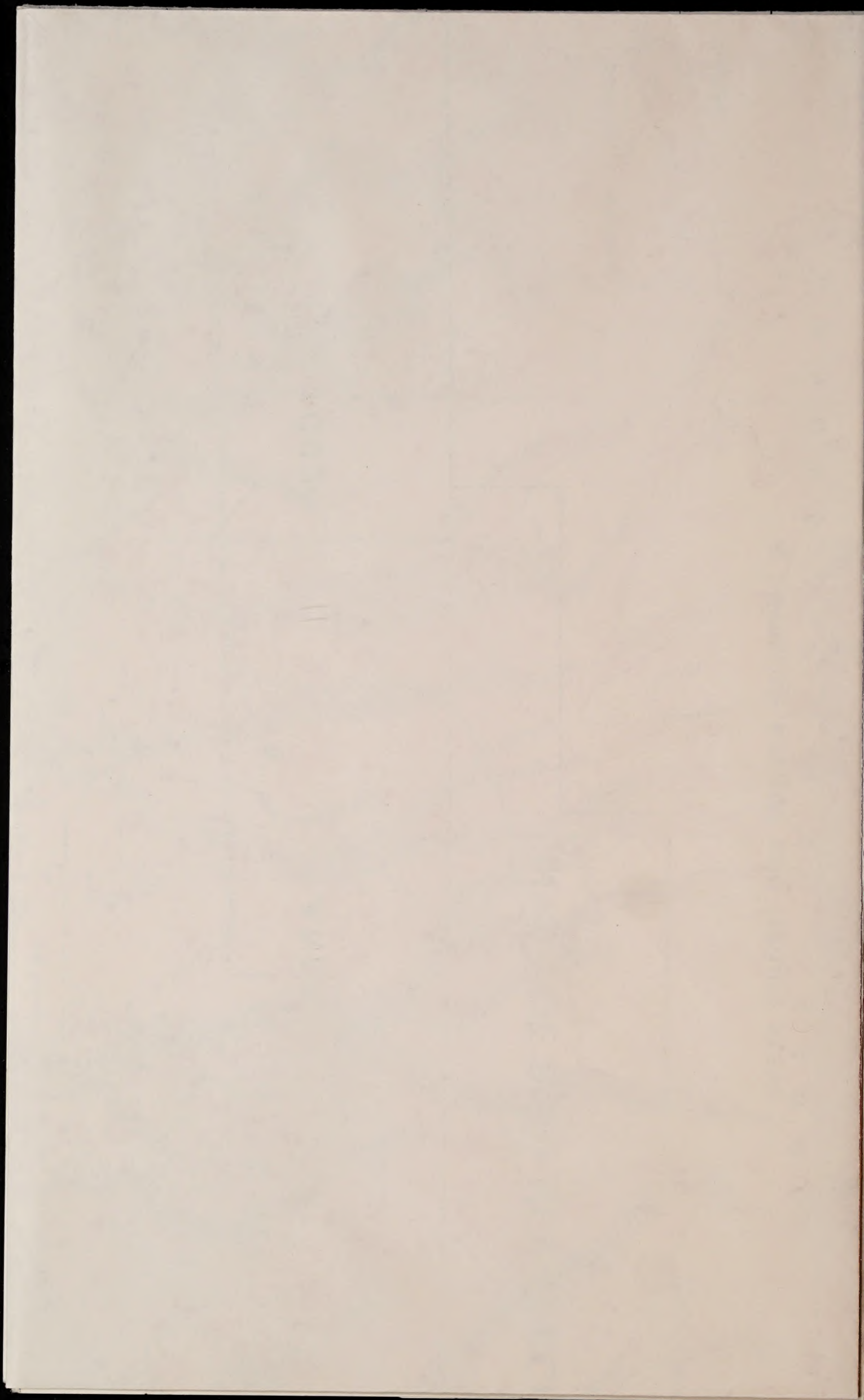
EXPLANATION

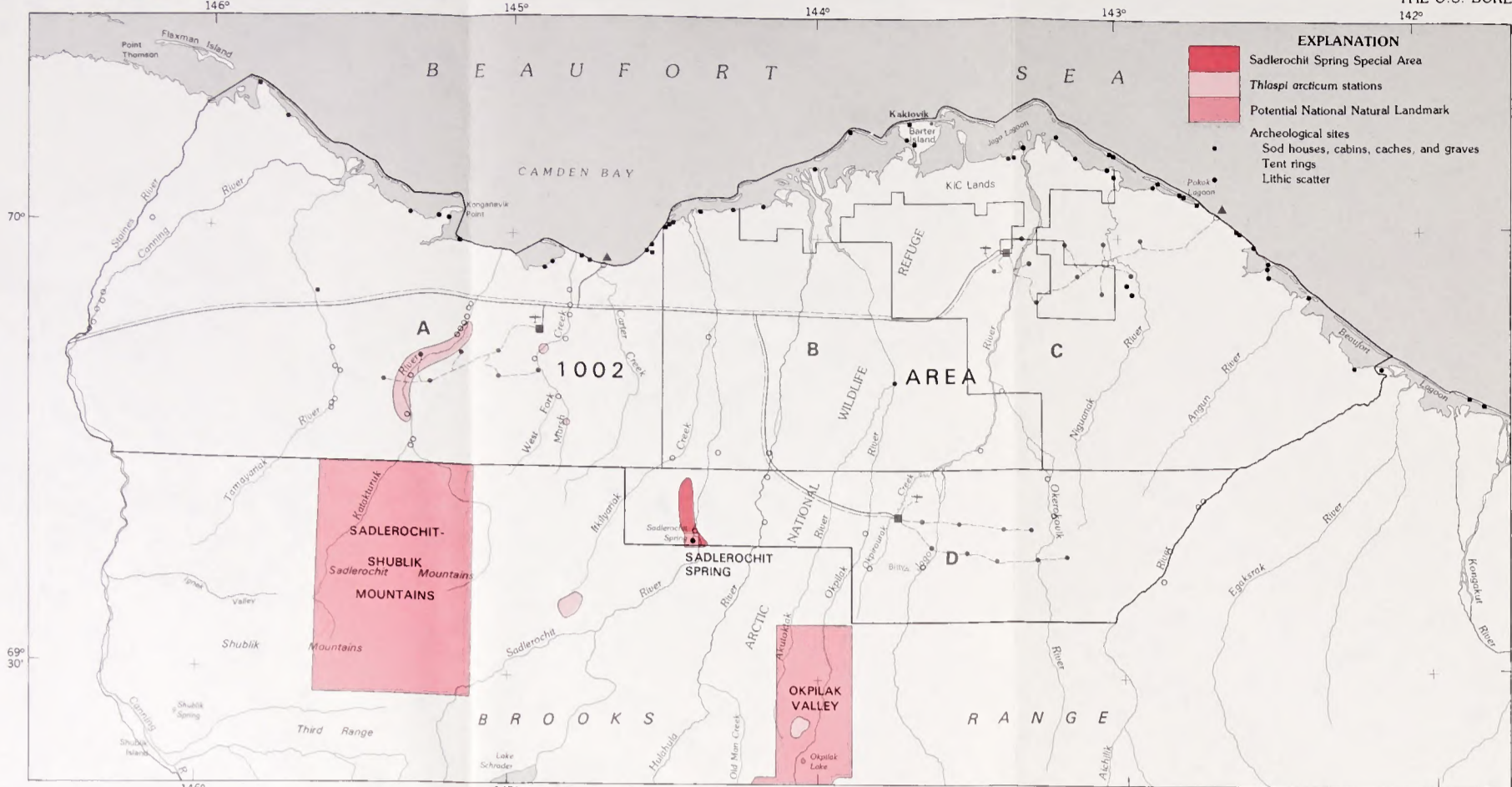
- 1. 1950-1955 (shaded area)
- 2. 1956-1960 (stippled area)
- 3. 1961-1965 (cross-hatched area)
- 4. 1966-1970 (diagonal lines)
- 5. 1971-1975 (horizontal lines)
- 6. 1976-1980 (vertical lines)
- 7. 1981-1985 (dotted area)
- 8. 1986-1990 (solid black area)



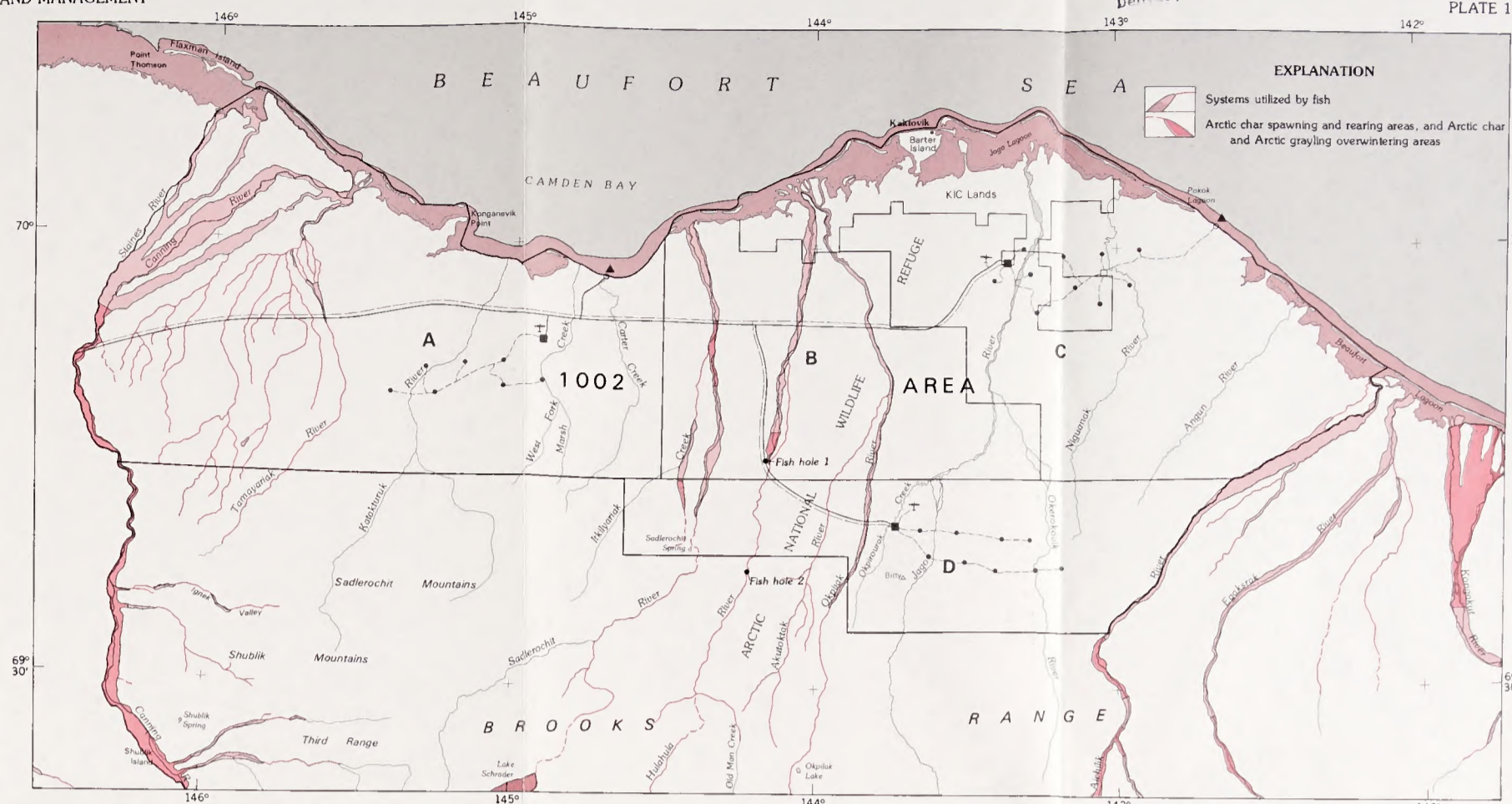
1460

B

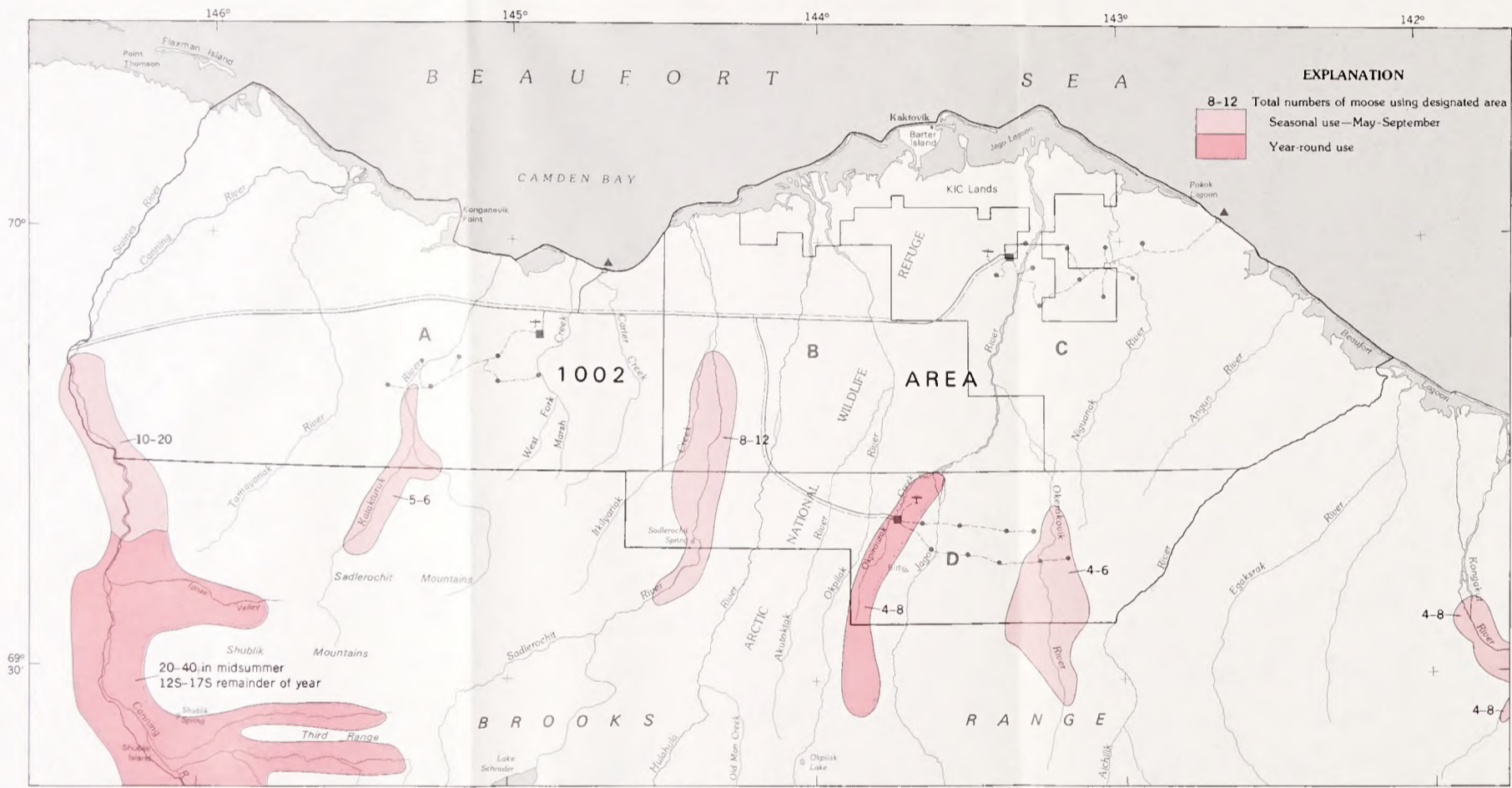




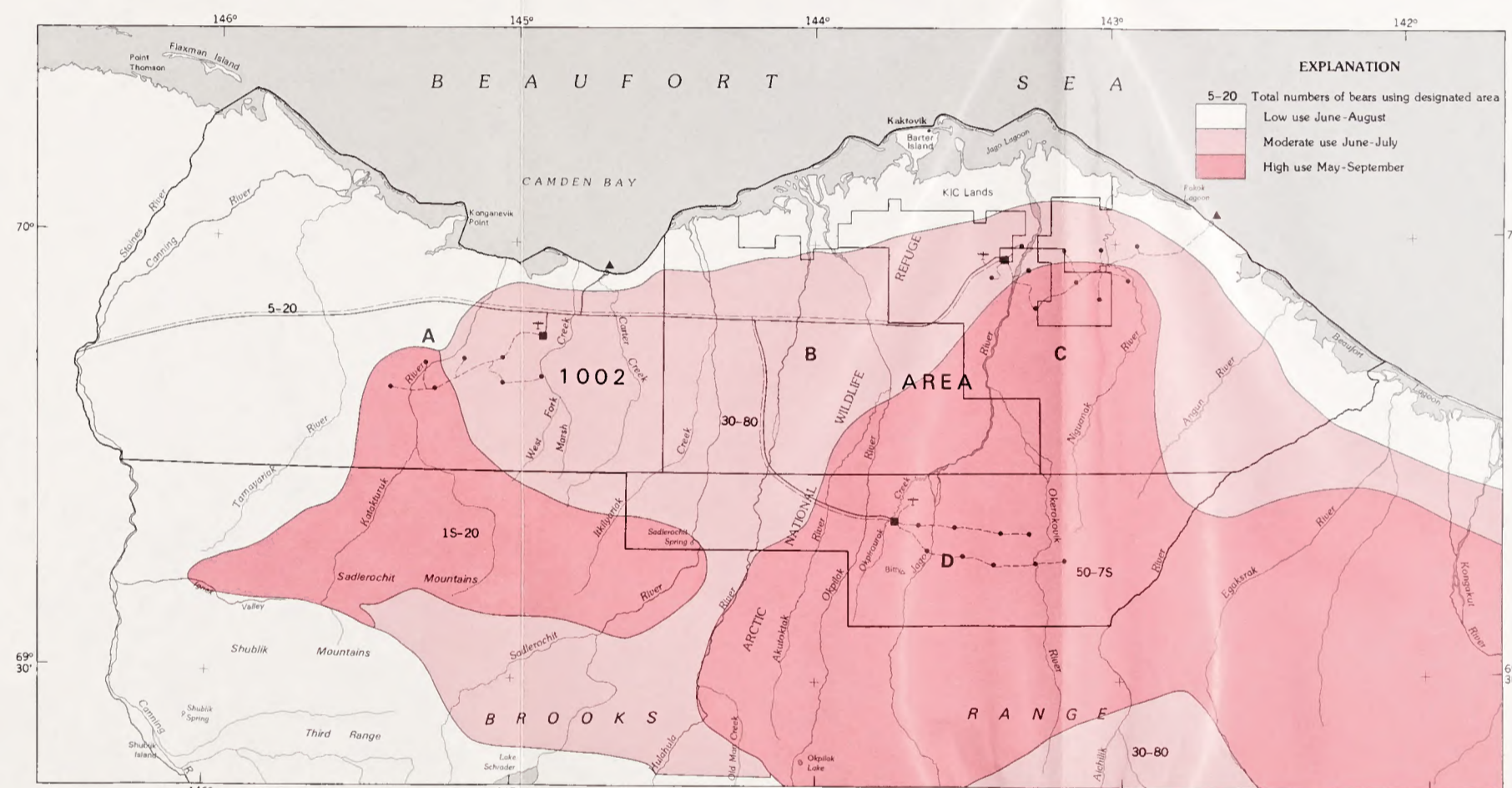
A. Potential national natural landmarks and archeological and other special sites



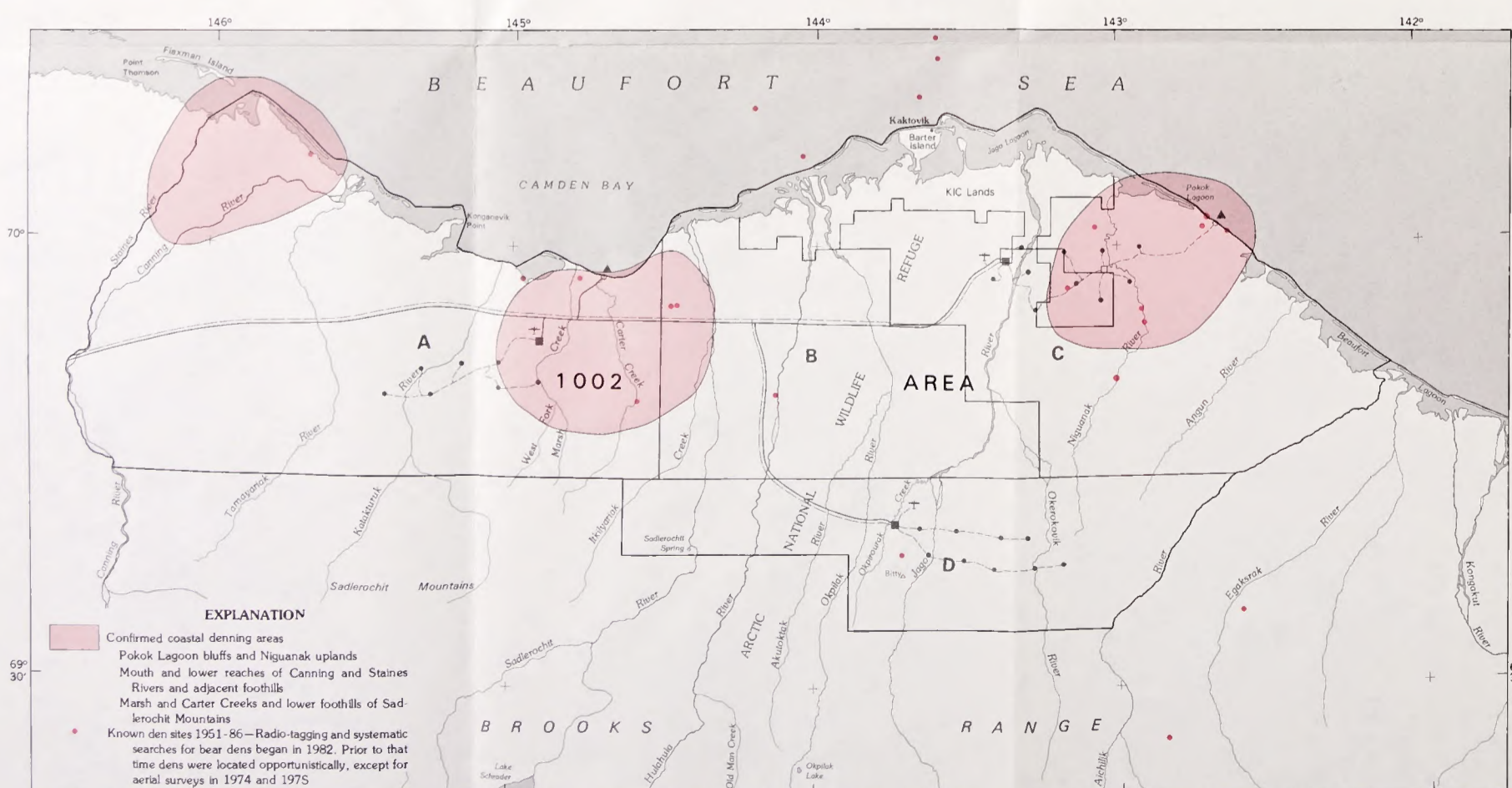
B. Fishery resources



C. Moose



D. Brown bear

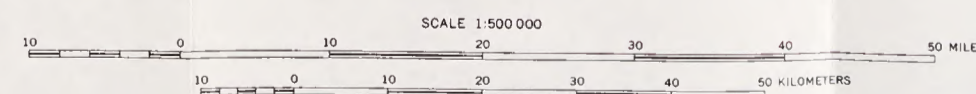


E. Polar bear

Base from U.S. Geological Survey, scale 1:250,000;
Barter Island, Denman Reef, and
Flaxman Island, 1955. Limited revision 1983
M. Michelson, 1958. Limited revision 1983

EXPLANATION OF FULL-LEASING DATA
[Data from figure V-1, this report]

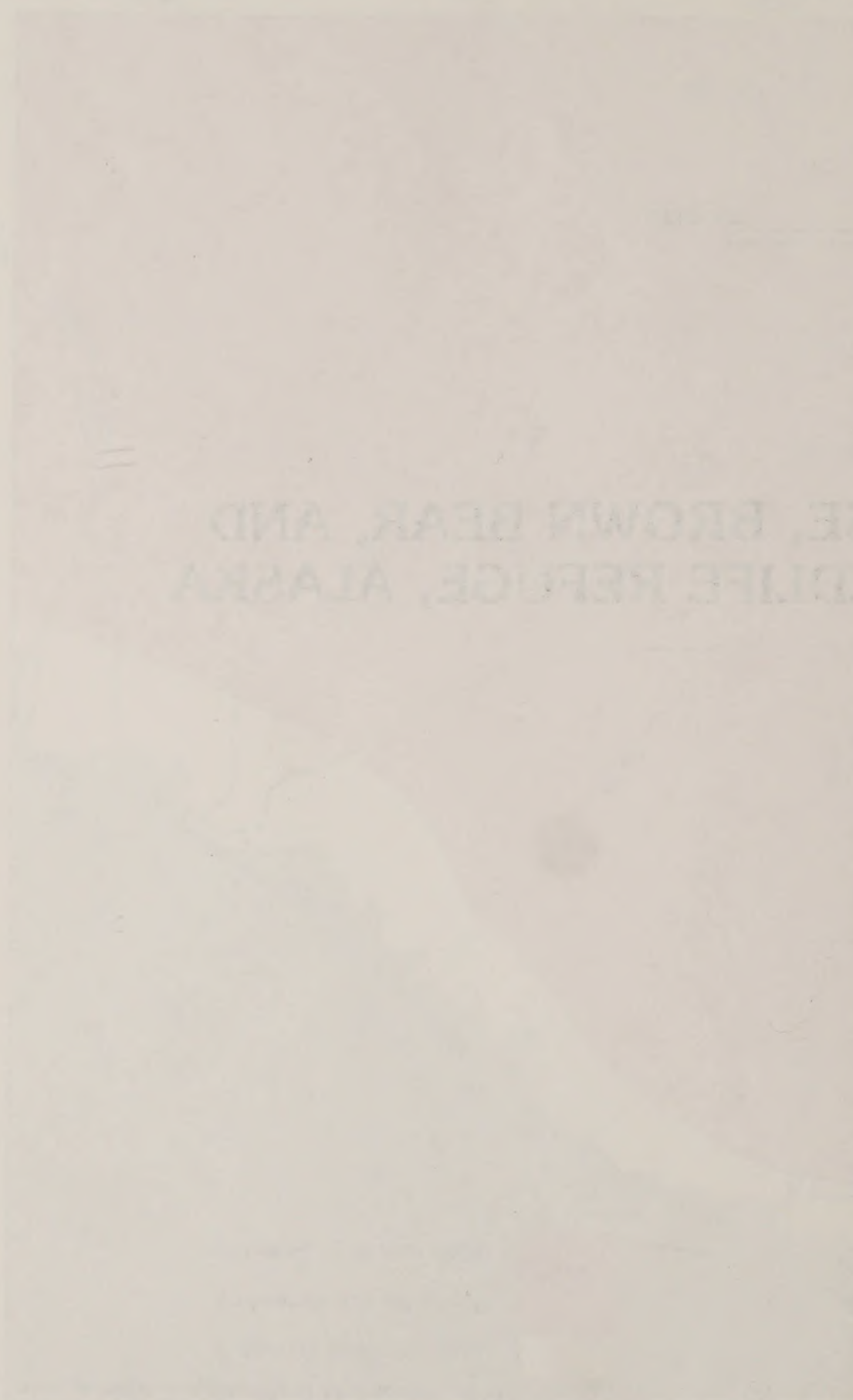
- | | | |
|-------------------------------|---|------------------------------------|
| ■ Possible facilities | + | Possible facilities |
| □ Central production facility | + | Arstrip—30 or 130 acres |
| ○ 90 acres | — | Haul road |
| ○ 40 acres | — | Connecting road |
| ○ Drill pad | — | Seawater treatment plant |
| ○ 23 acres | ○ | Port facility |
| ○ Pipeline | ○ | Assessment block discussed in text |



MAPS OF ARCHEOLOGICAL AND NATURAL AREAS, FISHERY, MOOSE, BROWN BEAR, AND POLAR BEAR RESOURCES IN THE 1002 AREA, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

Compiled by the U.S. Fish and Wildlife Service

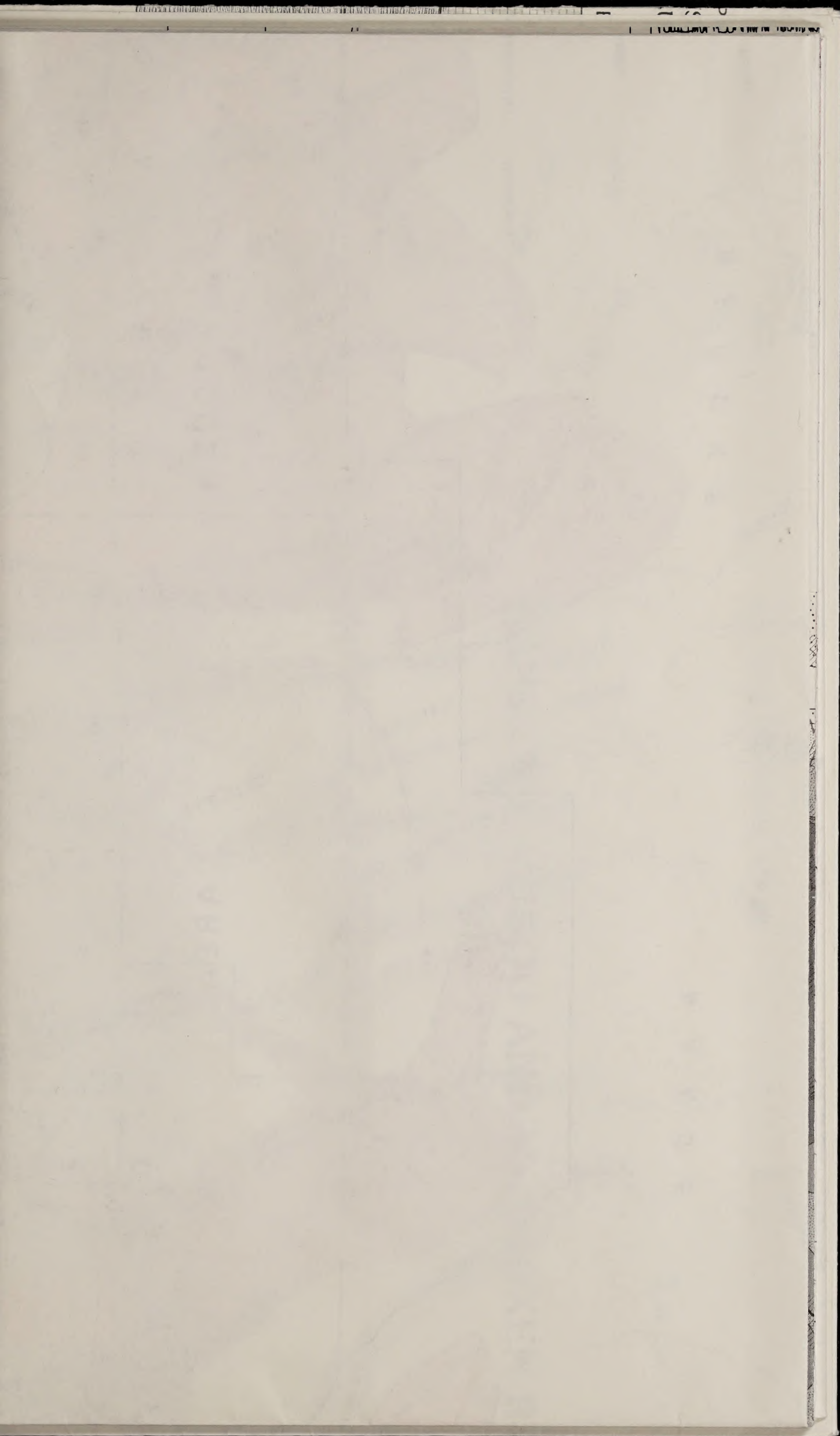
Symbol	Description	Quantity
▲	Point of Interest	1
□	Area of Interest	1



EXPLANATION

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Date from form V-1 (if known)

County for action being

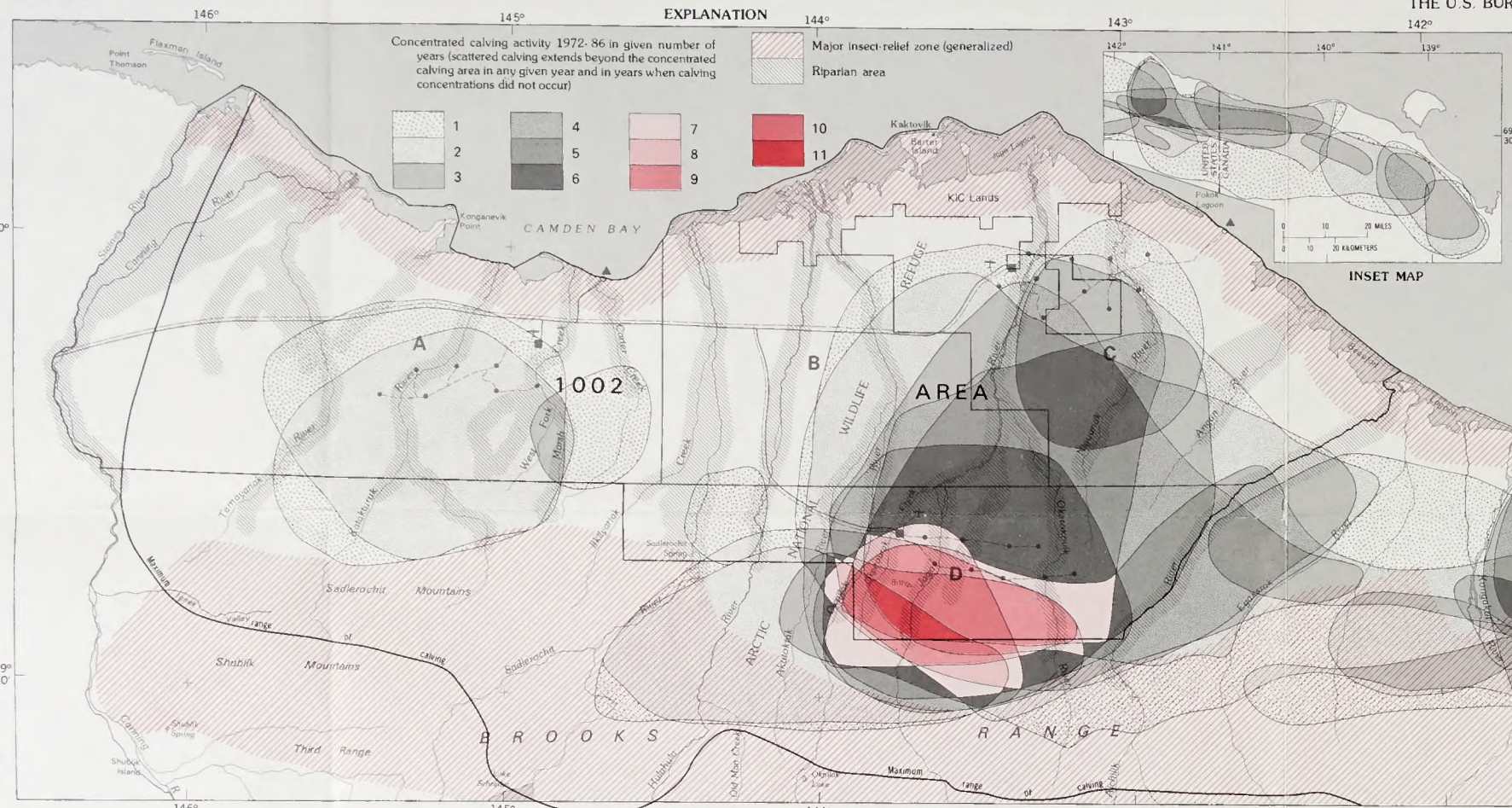
1	1st class	1st class
2	2nd class	2nd class
3	3rd class	3rd class
4	4th class	4th class
5	5th class	5th class
6	6th class	6th class
7	7th class	7th class
8	8th class	8th class
9	9th class	9th class
10	10th class	10th class

KATIE BROWN BEAR AND
TIMPHE REFUGE, ALASKA

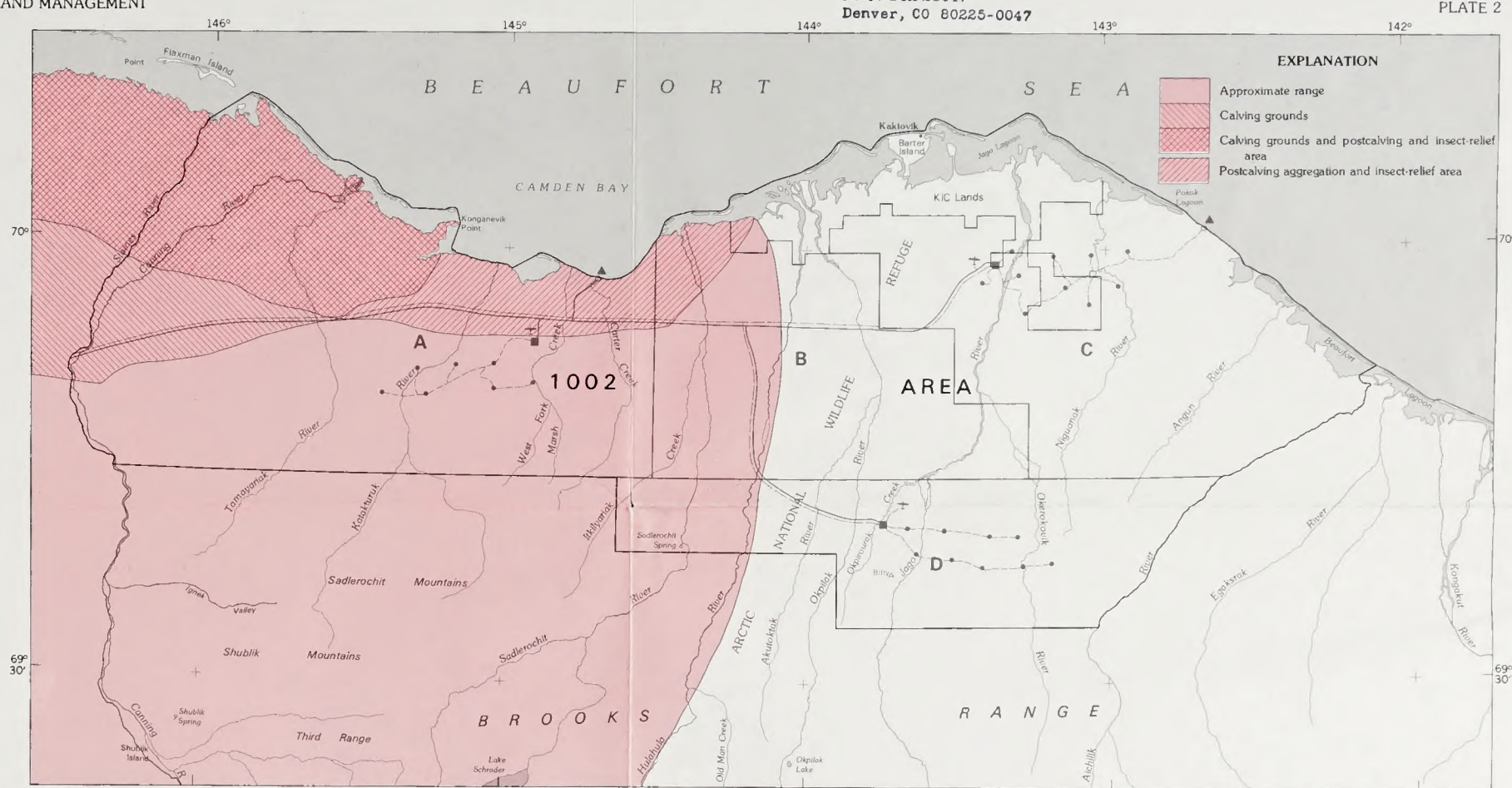
EXPLANATION

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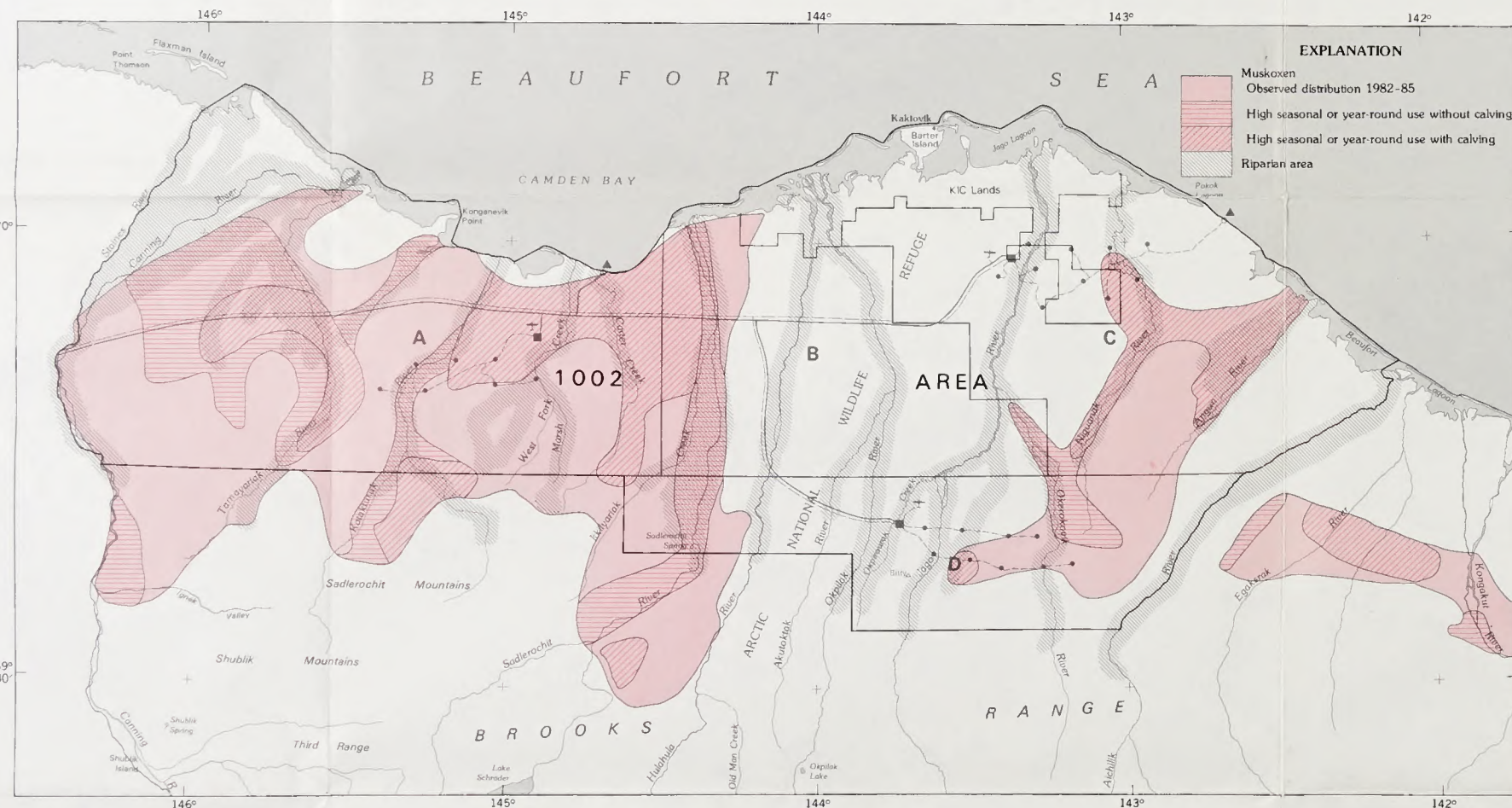
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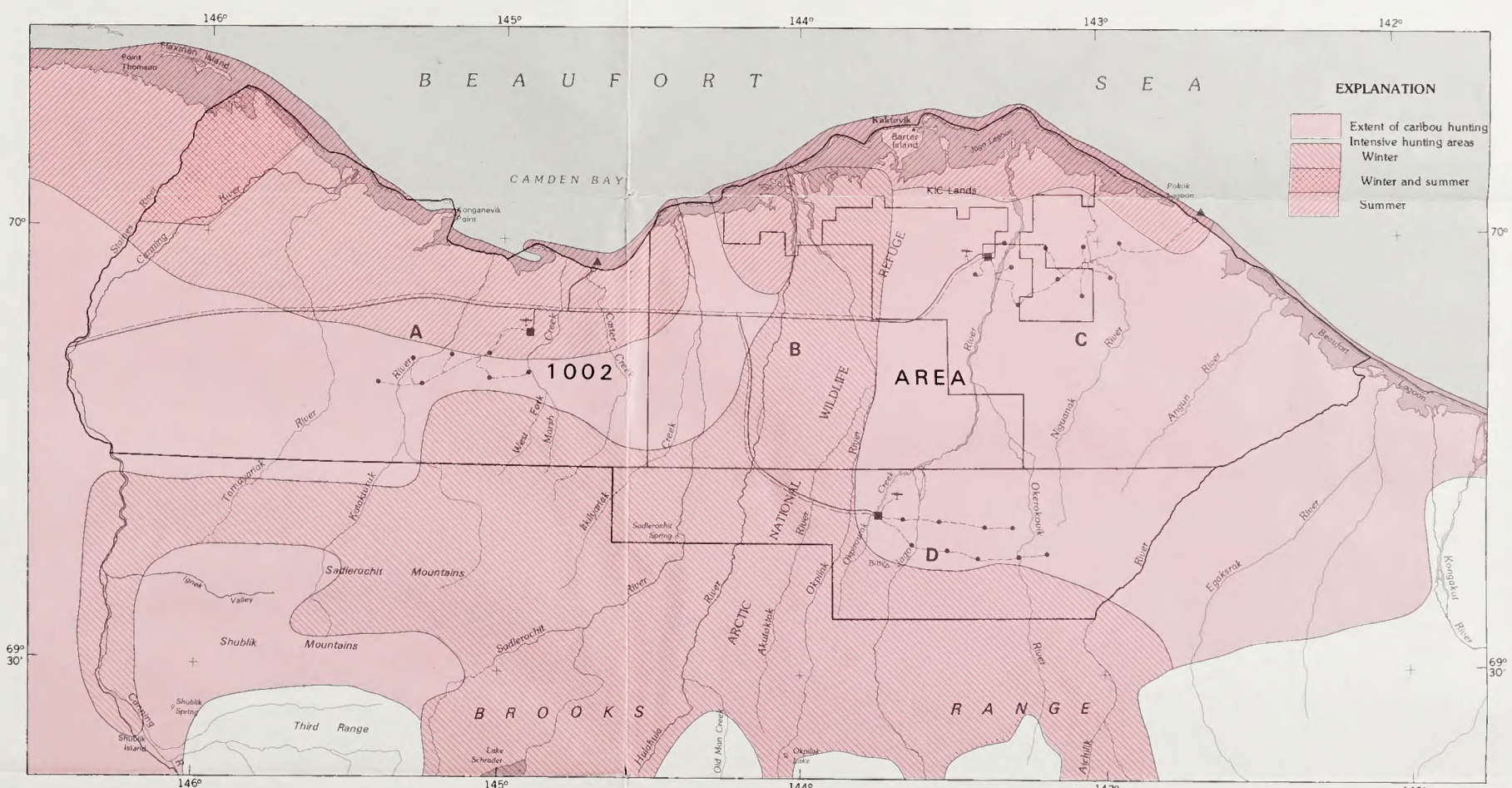
A. Porcupine caribou herd concentrated calving and insect-relief areas



B. Central Arctic caribou herd

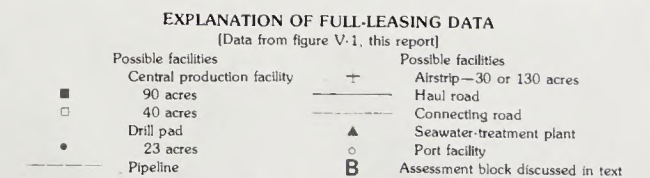
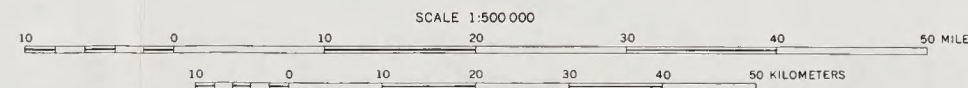


C. Muskoxen and riparian areas



D. Caribou subsistence-hunting area

Base from U.S. Geological Survey, scale 1:250,000.
Barter Island, Demarcation Point, and
Flaxman Island, 1955. Limited revision 1983
Mt. Michelson, 1956. Limited revision 1983



MAPS OF CARIBOU AND MUSKOXEN RESOURCES IN THE 1002 AREA, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

Compiled by the U.S. Fish and Wildlife Service

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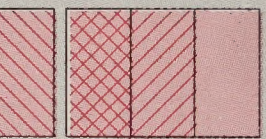
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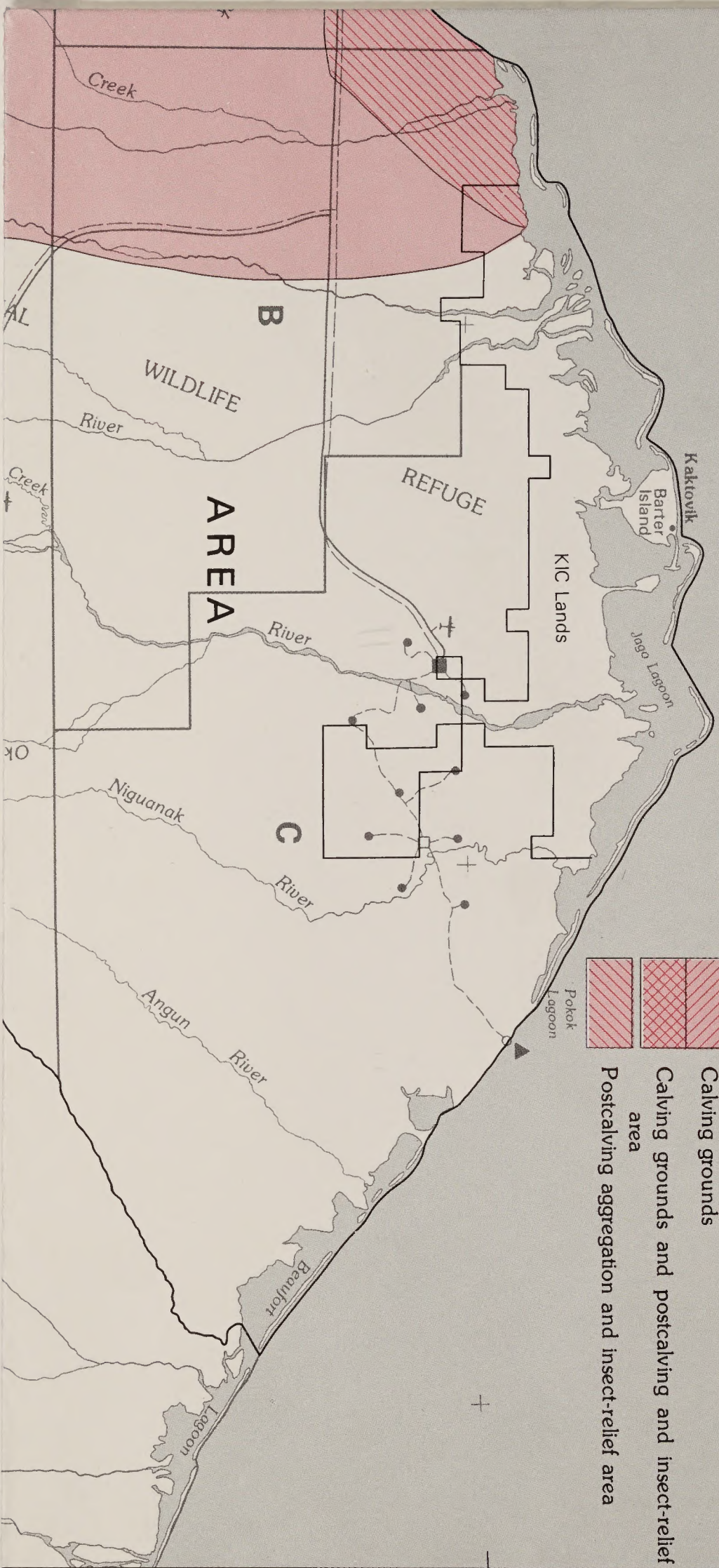
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EXPLANATION



Approximate range
Calving grounds
Calving grounds and postcalving area
Postcalving aggregation and insect-relief area

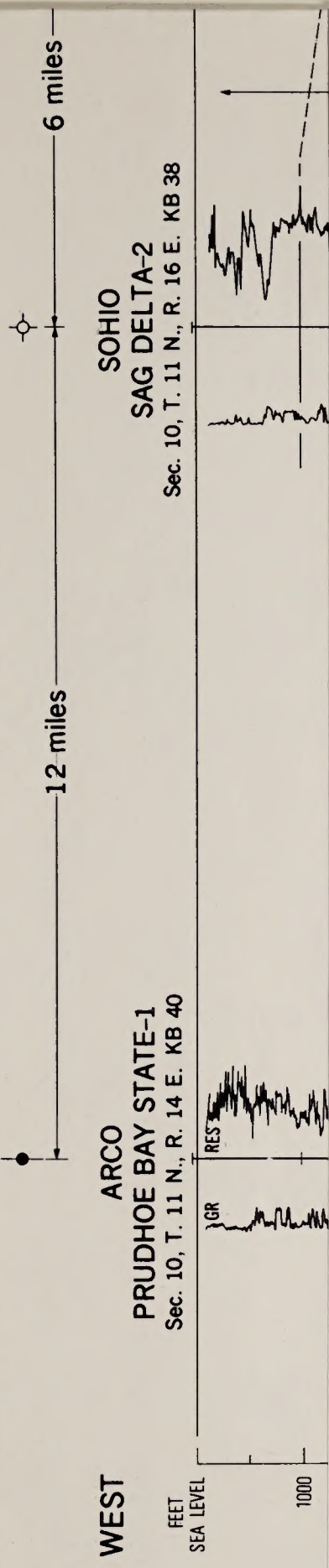


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1002 AREA

PLATE 2

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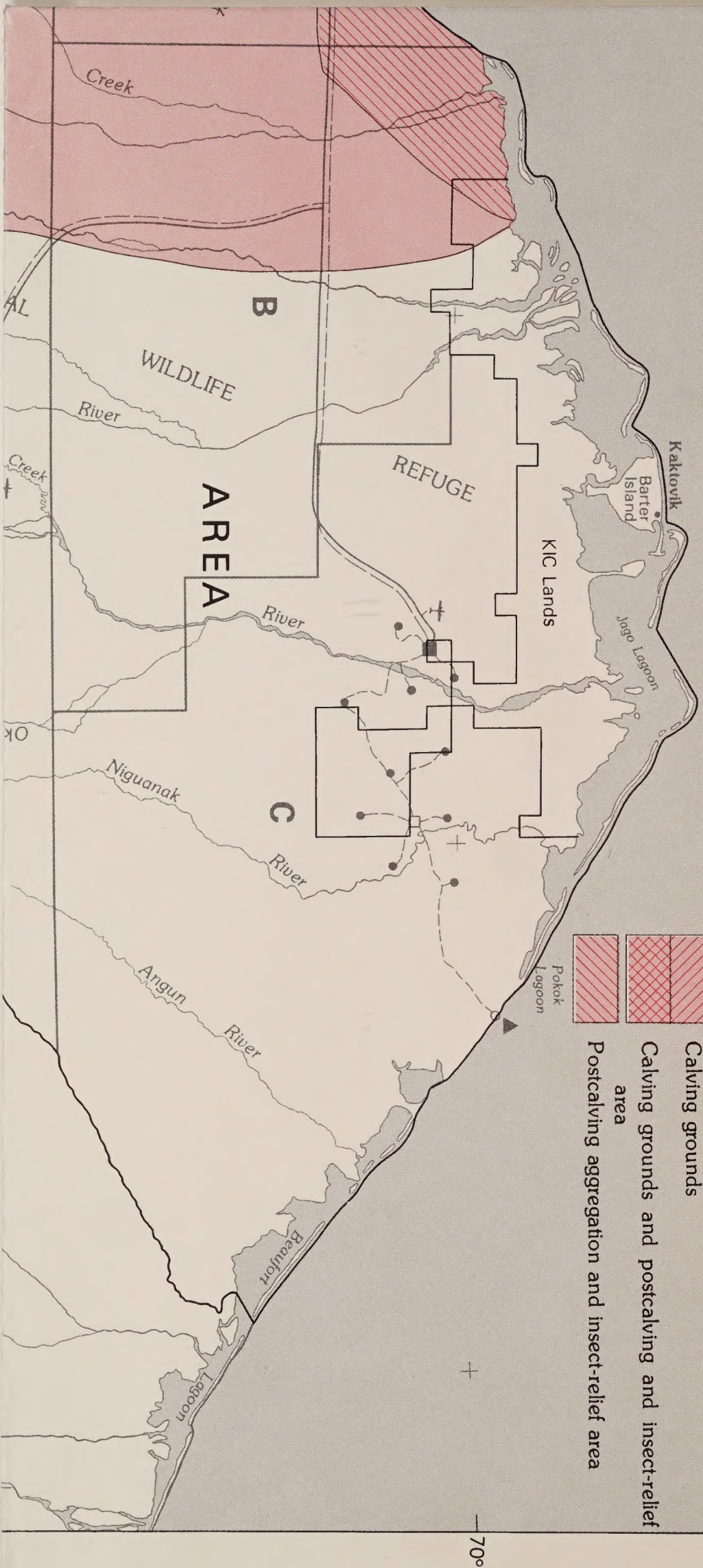
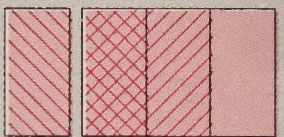
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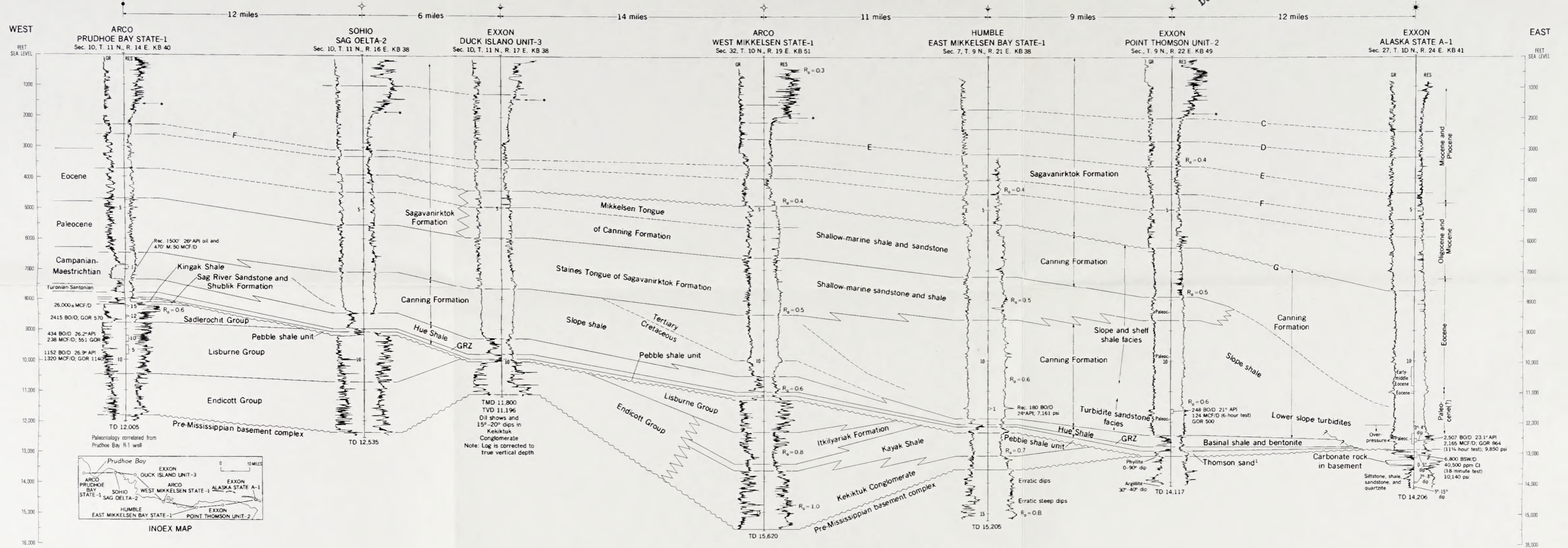
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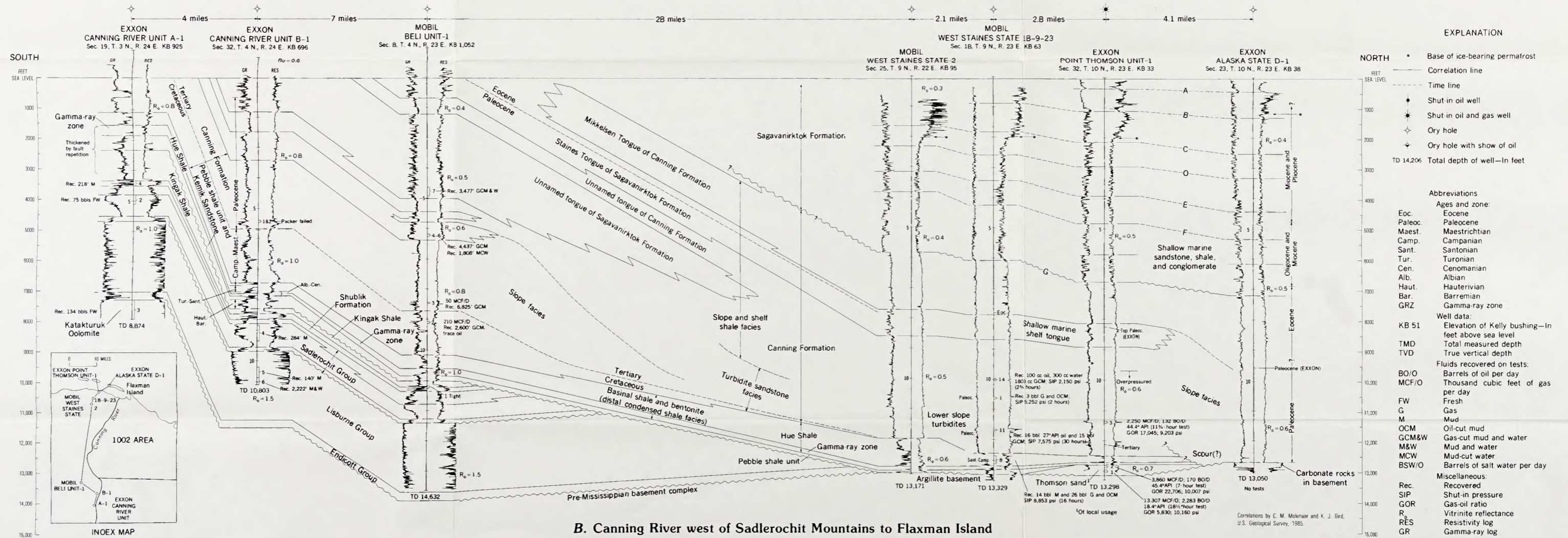
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A. Prudhoe Bay to Flaxman Island



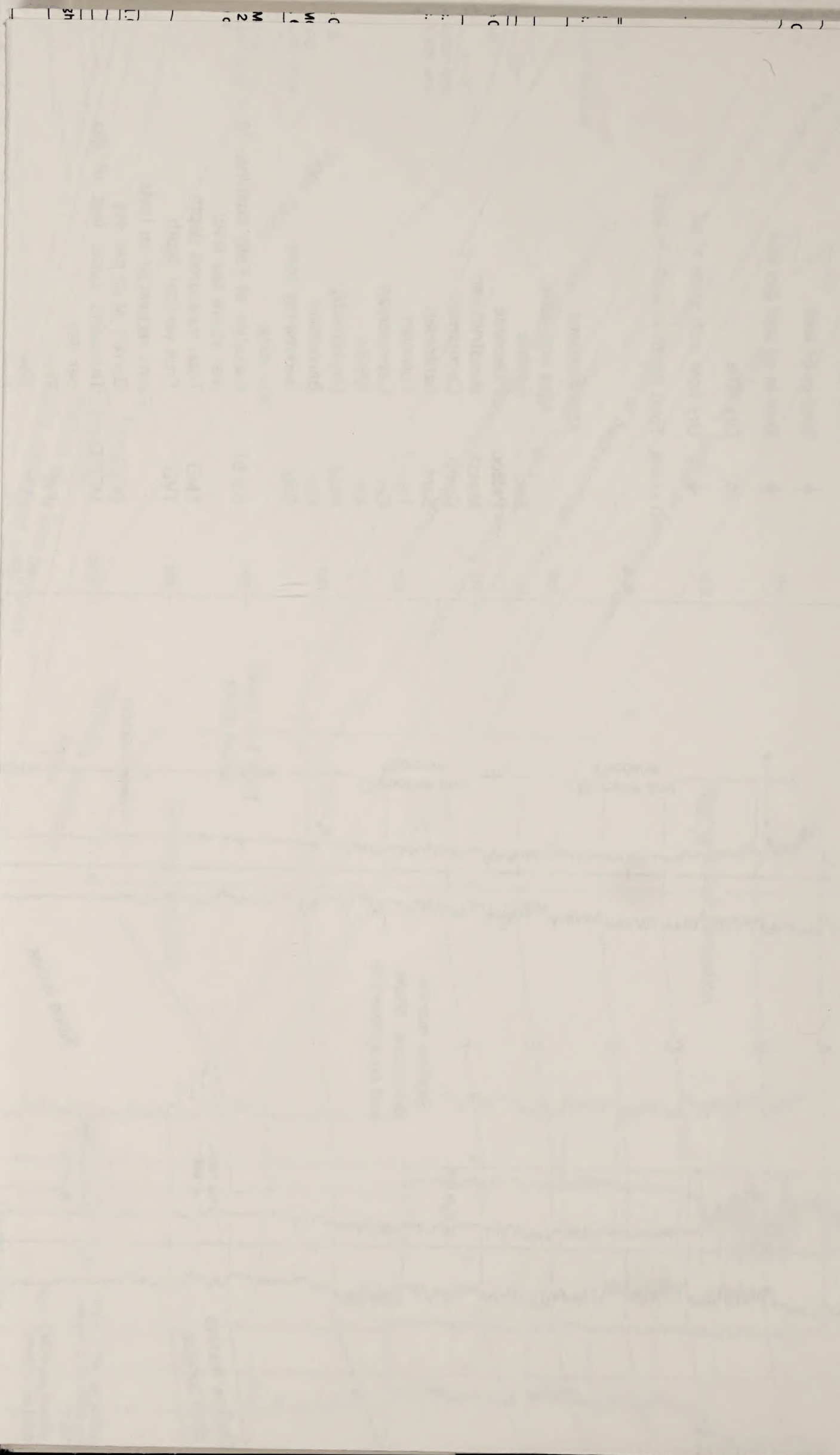
B. Canning River west of Sadlerochit Mountains to Flaxman Island

WELL CORRELATION SECTIONS SHOWING SELECTED DATA, NORTHEASTERN ALASKA

EXPLANATION

- Base of ice-bearing permafrost
- Correlation line
- Time line
- ◆ Shut-in oil well
- ◆ Shut-in oil and gas well
- ◆ Dry hole
- ◆ Dry hole with show of oil
- TD 14,206 Total depth of well—In feet
- Abbreviations**
- Ages and zone:**
- Eoc. Eocene
- Paleoc. Paleocene
- Maest. Maestrichtian
- Camp. Campanian
- Sant. Santonian
- Tur. Turonian
- Cen. Cenomanian
- Alb. Albian
- Haut. Hauterivian
- Bar. Barremian
- GRZ Gamma-ray zone
- Well data:**
- KB 51 Elevation of Kelly bushing—In feet above sea level
- TMD Total measured depth
- TVD True vertical depth
- Fluids recovered on tests:**
- BO/O Barrels of oil per day
- MCF/O Thousand cubic feet of gas per day
- FW Fresh
- G Gas
- M Mud
- OCM Oil-cut mud
- GCM&W Gas-cut mud and water
- M&W Mud and water
- MCW Mud-cut water
- BSW/O Barrels of salt water per day
- Miscellaneous:**
- Rec. Recovered
- SIP Shut-in pressure
- GOR Gas-oil ratio
- R_v Vitrinite reflectance
- RES Resistivity log
- GR Gamma-ray log

Correlations by C. M. Molnar and K. J. Bird, U.S. Geological Survey, 1985.

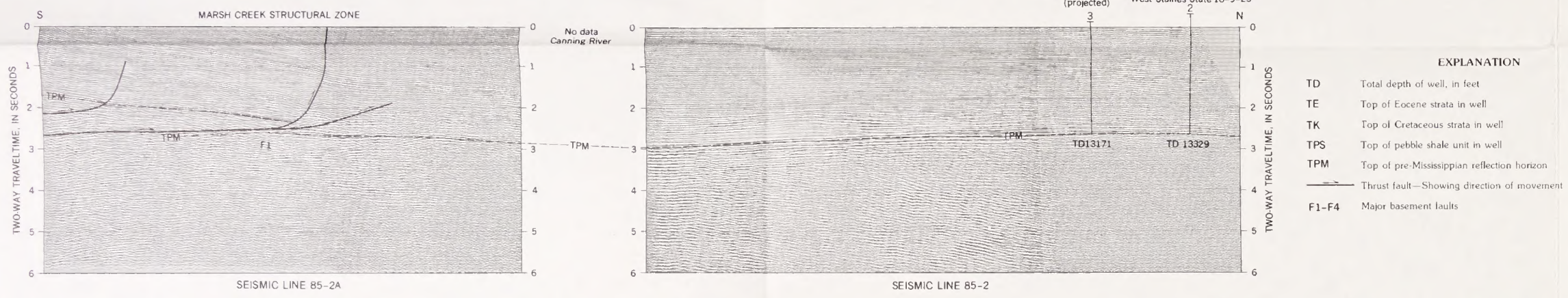
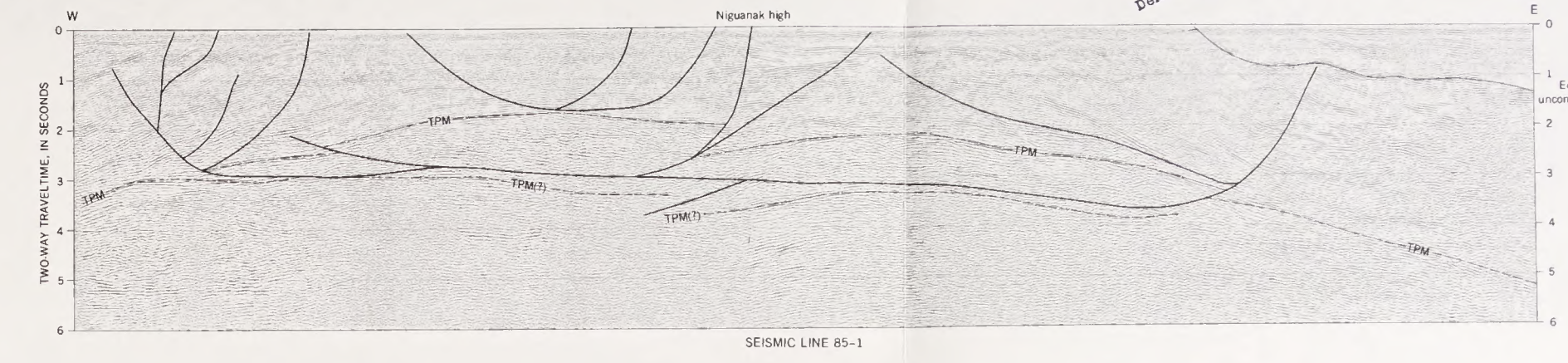
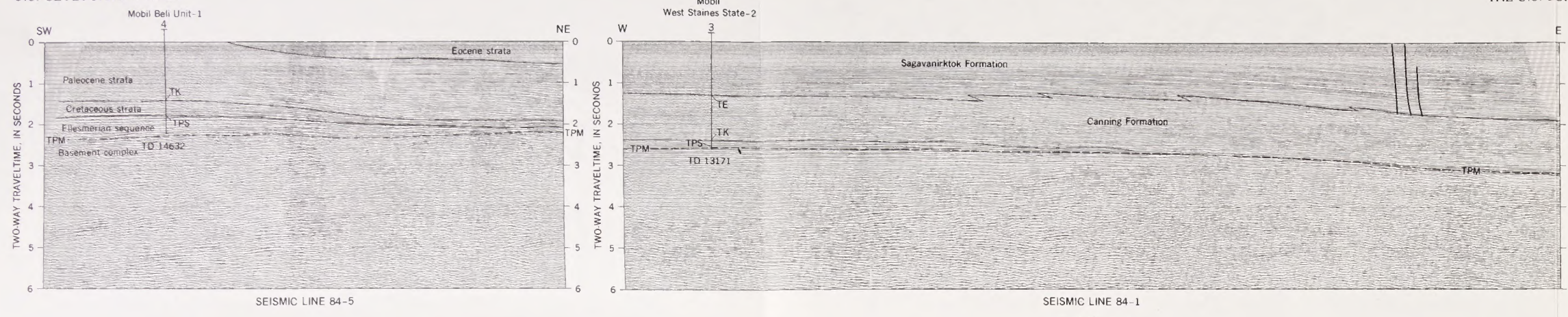


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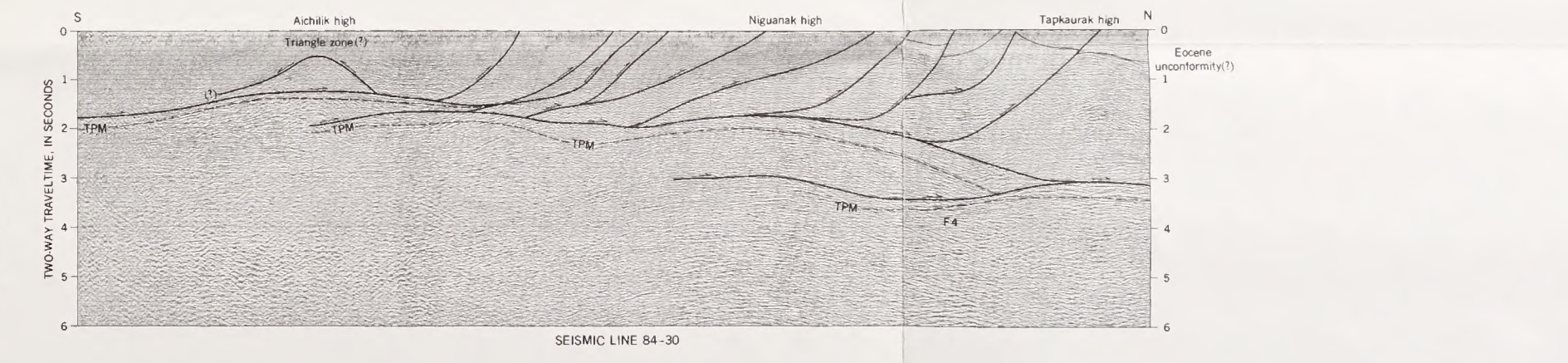
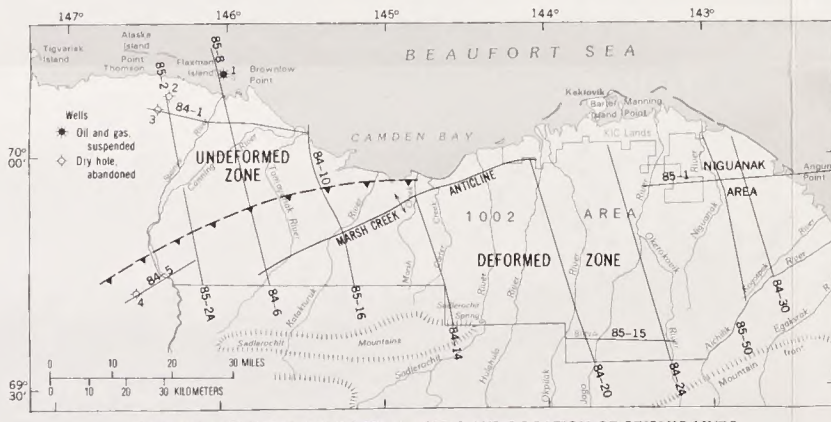
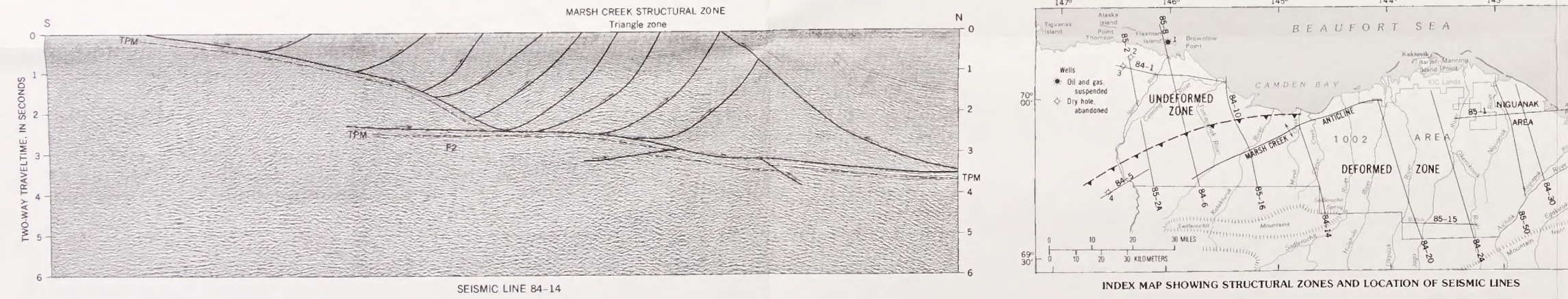
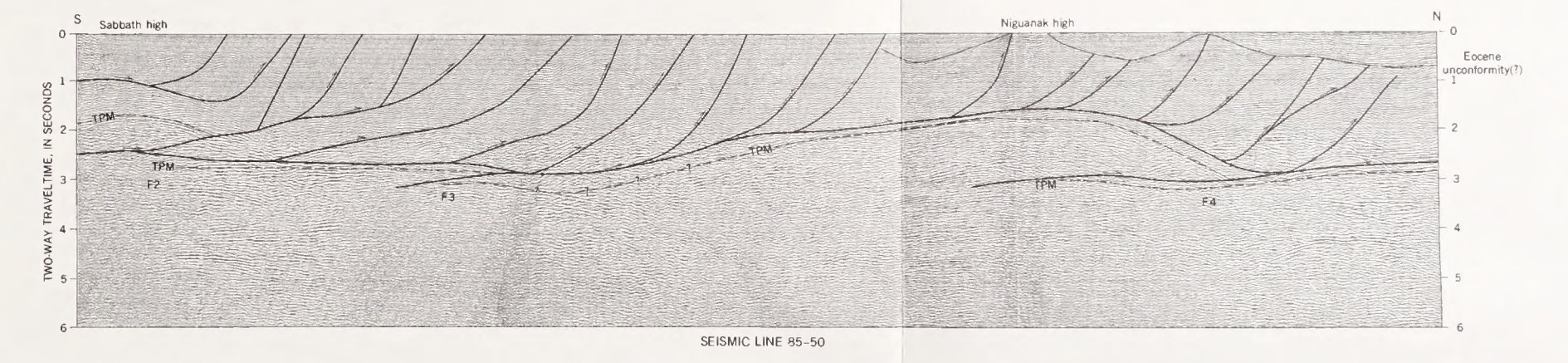
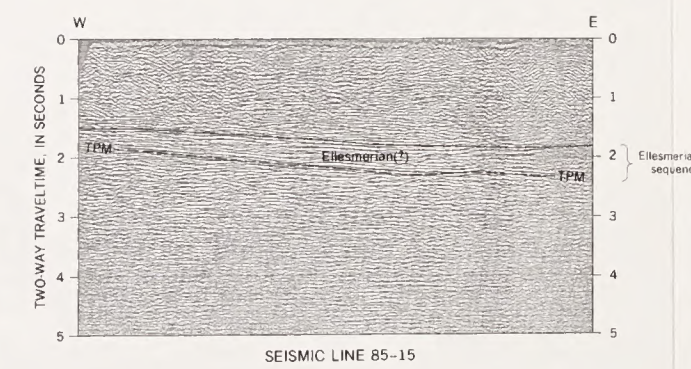
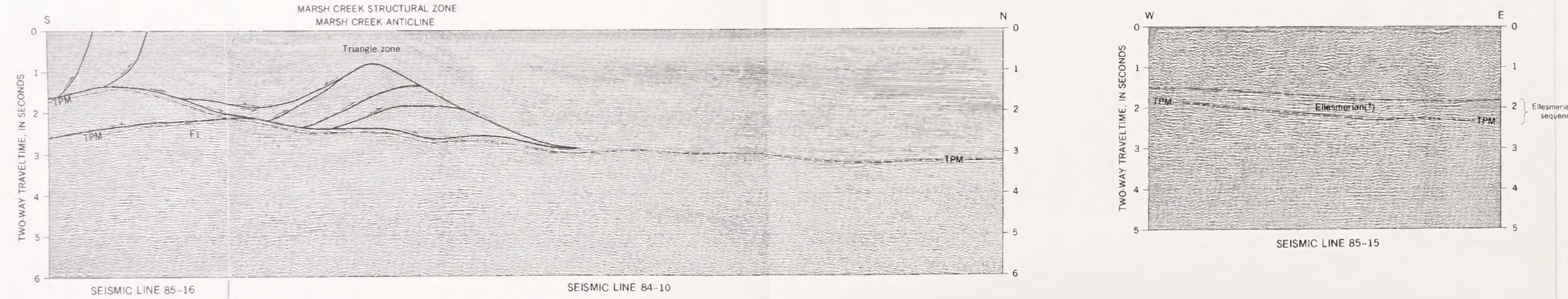
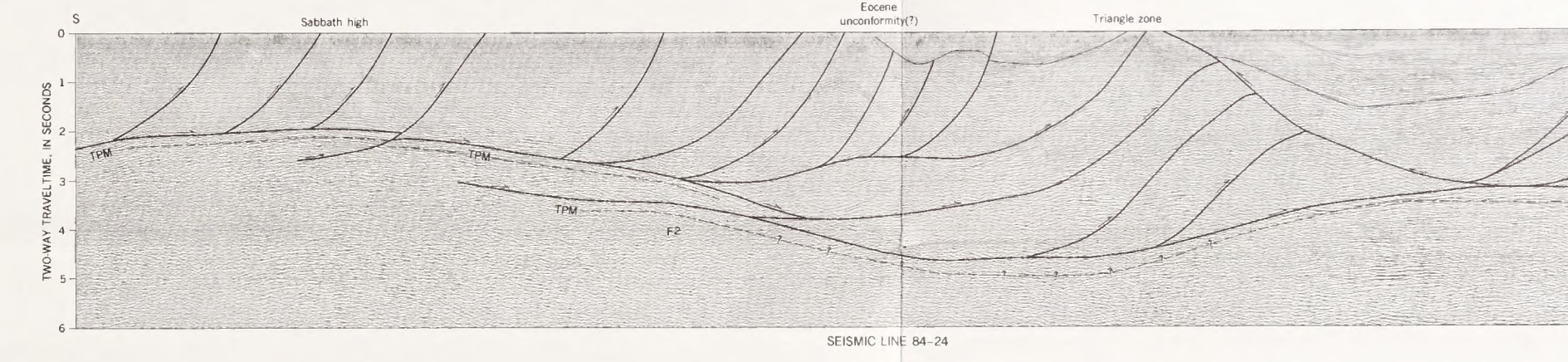
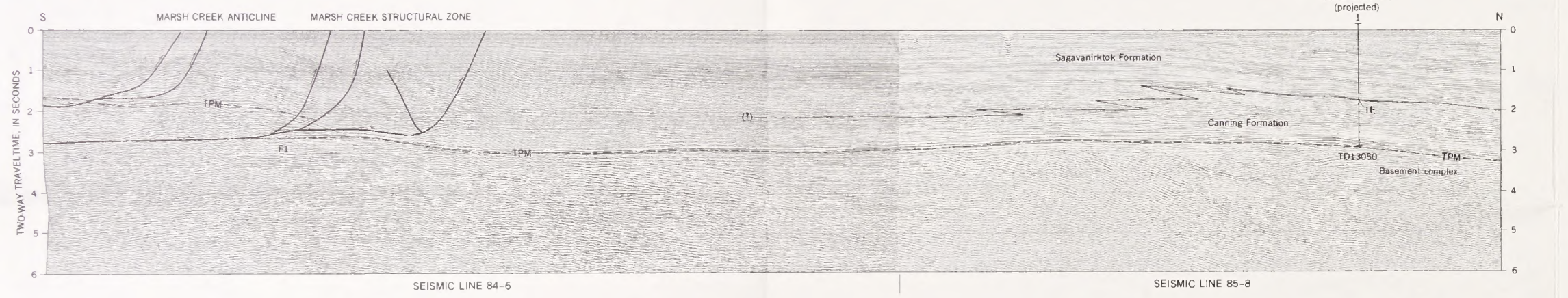
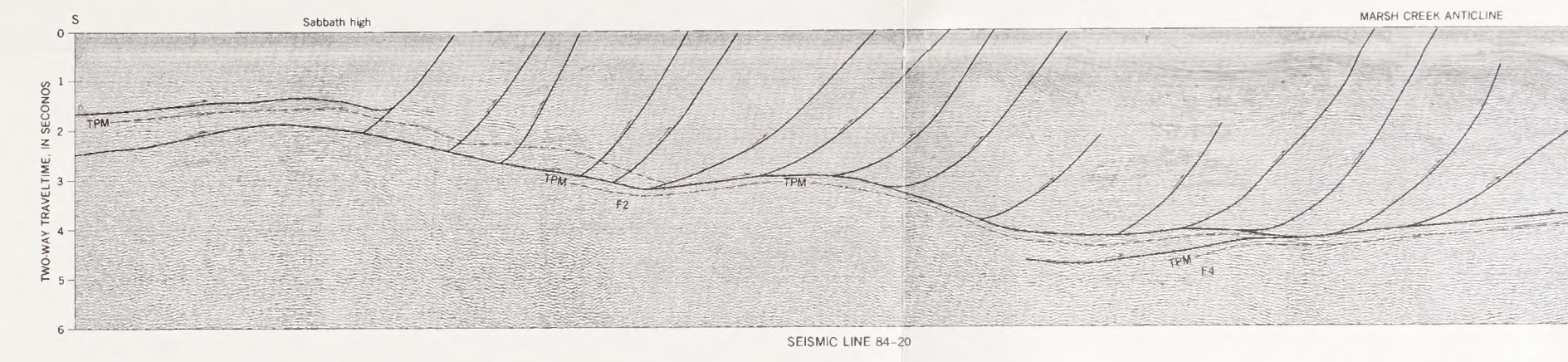


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EXPLANATION

- TD Total depth of well, in feet
- TE Top of Eocene strata in well
- TK Top of Cretaceous strata in well
- TPS Top of pebble shale unit in well
- TPM Top of pre-Mississippian reflection horizon
- Thrust fault—Showing direction of movement
- F1-F4 Major basement faults



Seismic lines processed by
W. J. Lovick and J. J. Miller,
U.S. Geological Survey, 1984-85,
and interpreted by J. R. Brant
and M. A. Fisher,
U.S. Geological Survey, 1985.

SELECTED SEISMIC LINES ACROSS THE 1002 AREA, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

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R'S CARD

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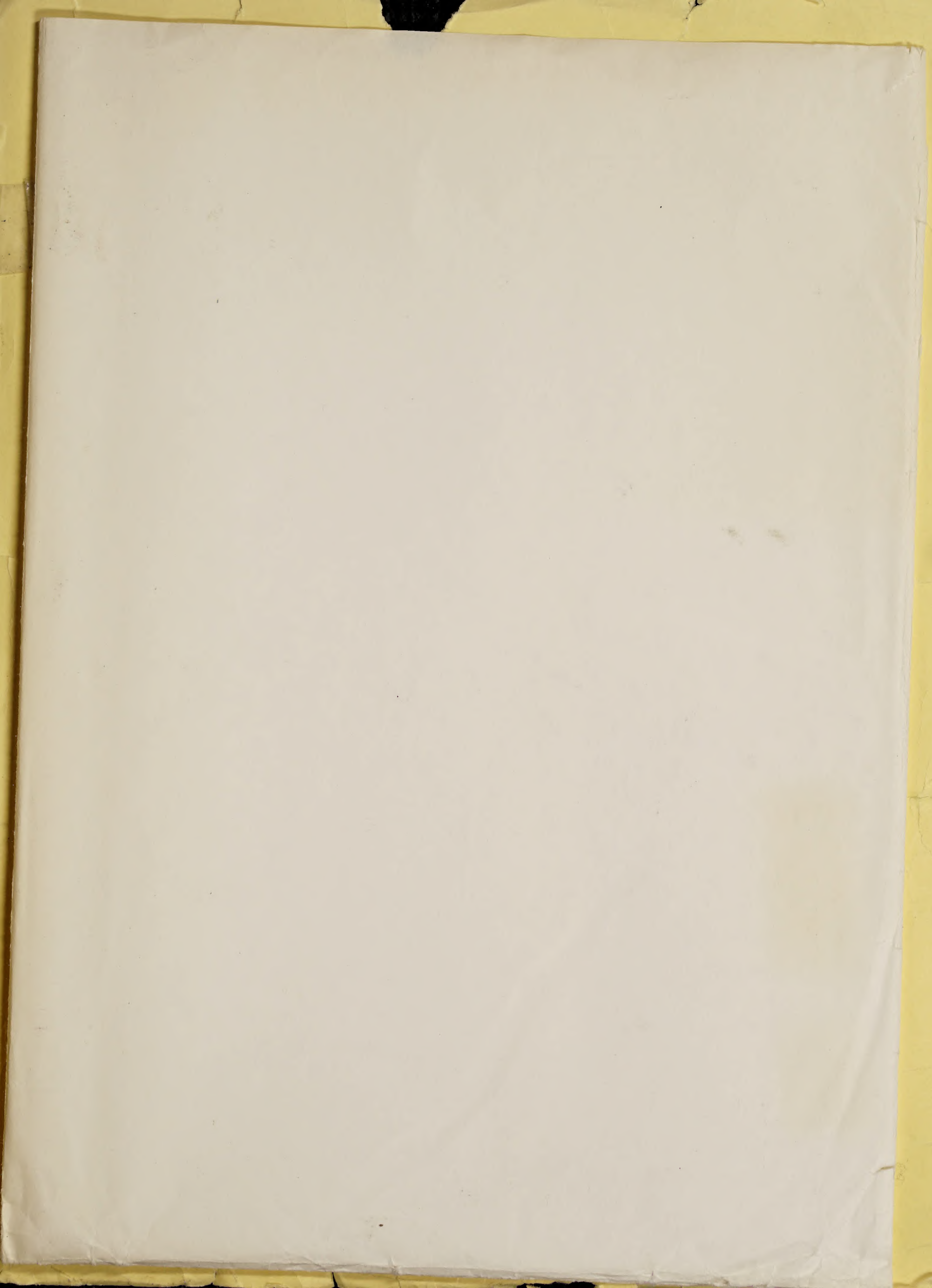
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Metropolitan	SSC-3071	1/2/91
State	144	

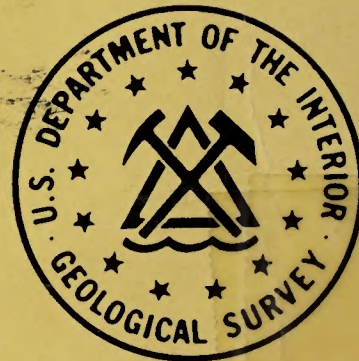
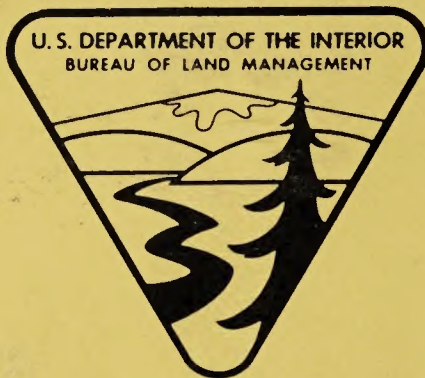
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